A COMPARISON OF MARGINAL ACCURACY OF COMMERCIALLY AVAILABLE INLAY WAX,AUTO-POLYMERIZED & LIGHT- POLYMERISED PATTERN RESIN MATERIAL BEFORE AND AFTER FABRICATION OF CASTING-AN IN VITRO STUDY

Dissertation submitted to

THE TAMIL NADU Dr M.G.R. MEDICAL UNIVERSITY

In partial fulfilment for the degree of

MASTER OF DENTAL SURGERY

BRANCH – I

PROSTHODONTICS AND CROWN & BRIDGE

APRIL – 2016

CERTIFICATE

This is to certify that the dissertation titled **" A comparison of marginal accuracy of commercially available inlay wax, auto-polymerized & light- polymerized pattern resin material before and after fabrication of casting-an in vitro study"** by **Dr Karrunakaran B**, post graduate student – MDS (Prosthodontics and Crown & Bridge- Branch- I), of KSR Institute of Dental Science and Research, Tiruchengode, submitted to the Tamil Nadu Dr. M.G.R. Medical University, Chennai, in partial fulfillment of the requirements for the MDS degree examination – April 2016- is a bonafide research work carried out by him under our supervision and guidance.

Dr C A MATHEW MDS.,
Guide, Professor and Head,
Dept. of Prosthodontics and
Crown & Bridge,
KSR Institute of Dental Science and
Research,
Tiruchengode – 637215

Dr G S KUMAR MDS.,
Principal,
KSR Institute of Dental Science
and Research,
Tiruchengode-637215

DECLARATION BY THE CANDIDATE

TITLE OF DISSERTATION	A COMPARISON OF MARGINAL ACCURACY OF COMMERCIALLY AVAILABLE INLAY WAX,AUTO-POLYMERIZED & LIGHT- POLYMERISED PATTERN RESIN MATERIAL BEFORE AND AFTER FABRICATION OF CASTING-AN IN VITRO STUDY
PLACE OF STUDY	K.S.R. Institute of Dental Science and Research
DURATION OF COURSE	3 Years
NAME OF THE GUIDE	DR.C.A.MATHEW
HEAD OF THE DEPARTMENT	DR.C.A.MATHEW

I hereby declare that no part of the dissertation will be utilized for gaining financial assistance for research or other promotions without obtaining prior permission of the Principal, K.S.R Institute of Dental Science and Research, Tiruchengode. In addition, I declare that no part of this work will be published either in print or electronic without the guide who has been actively involved in the dissertation. The author has the right to reserve publishing of work solely with prior permission of the Principal, K.S.R Institute of Dental Science and Research, Tiruchengode.

Head of the Department **Guide** **Signature of the Candidate**

ACKNOWLEDGEMENTS

I express my sincere thanks to **Thiru. Lion Mr. K .S .Rangasamy M.J.F**., founder and chairman, KSR Group of Educational Institutions, for providing an to undergo post-graduation in this esteemed institution.

I would like to thank **Dr. G. S .Kumar MDS**, Principal, KSR Institute of Dental Science and Research, for his encouragement and support.

I would like to express my special thanks to **Dr. Sudhakara Maller MDS, Dr.Udita Maller MDS,** who helped me to form a title for this study.

First and Foremost, I would like to express my sincere gratitude to my advisor Prof. **Dr.C.A.MATHEW MDS** for his continuous support to all my work throughout the course, for his patience, motivation, enthusiasm, and immense knowledge. I could not have imagined having a better advisor and mentor for my post graduation.

I would also like to show gratitude to my prosthodontic department staffs, including Dr**.N.VIDYA SANKARI** MDS, Dr**.K.S.KARTHIK** MDS, Dr. **RACHURI NARENDRA KUMAR**, MDS, Dr. **R. MANIKANDAN**, MDS, **Dr.MUTHUVIGNESH** J, MDS, DR. **S. SURESH KUMAR** MDS, Dr.**M.MAHESHWARAN** MDS, Dr. **NIRANJANA,** MDS, Dr.**RAJ KUMAR,**MDS. I am so deeply grateful for their help, professionalism, and valuable guidance throughout the course that I do not have enough words to express my deep and sincere appreciation.

Getting through my dissertation required more than academic support, and I have many, many people to thank for listening to and, at times, having to tolerate me over the past three years. I cannot begin to express my gratitude and appreciation for their friendship. Dr.**Brindha**,Dr. **Mohammed**, Dr. **Benny Thomas**, Dr. **Mithra Rajan**, Dr. **Satheesh**, Dr. **S.Arulkumar**, Dr**.S**. **Vinothkumar**, Dr. **Naveen kumar**, Dr. **Uma Maheshwari**, Dr.**M**. **Kanmani**, Dr**.R**. **Sai mahendran,** and Dr.**R.yogananthan** have been unwavering in their personal and professional support during my college hours.

I would also like to extend a huge and warm thanks to my teaching staff members, Non-teaching staff members and lab technicians of dept. of prosthodontics for their constant support.

For many memorable evenings out and in, I must thank Dr.**Allwyn Samuel**, Dr. **A**.**Dhanush Kodi** and Dr. **C.P.Sreedev**. Most importantly, none of this could have happened without my family .My Mother, who offered her encouragement through phone calls every week – despite my own limited devotion to correspondence. To my Father and my bother– it would be an understatement to say that, as a family, we have experienced some ups and downs in the past one year. Every time I was ready to quit, you did not let me and I am forever grateful. This Thesis stands as a testament to your unconditional love and encouragement.

CONTENTS

LIST OF FIGURES

LIST OF GRAPHS

LIST OF TABLES

LIST OF ABBREVATIONS

µm	Micrometer
ADA	American Dental Association
ANOVA	Analysis of Variance
gm	Gram
mm	Millimeter
°k	Degree Kelvin
°c	Degree Celsius
P	Probability
hr	hour
min	minutes
ml	milliliters
MMA	methylmethacrylate
SD	Standard deviation
SPSS	Statistical package for the social science
ppm	Parts per million
LC	Light cure
i.e	That is to say
n	sample
%	percentage
VLC	Visible light cure
P:L ratio	Powder: liquid ratio
Naocl	Sodium Hypochlorite
Bis GMA	Bisphenol-A glycidyl dimethacrylate
Fig	Figure
no	number
^{0}F	Fahrenheit
DMLS	Direct metal laser sintering
df	Degrees of freedom
sig	Significance level
et al	And others
SEM	Scanning electron microscope

TERMINOLOGIES

Aluminum oxide: A finely ground ceramic particle (frequently 50 µm) often used in conjunction with air-borne particle abrasion of metal castings before the application of porcelain as with metal ceramic restorations.

Ambient: Existing or present on all sides; encompassing.

Auto polymerizing resin: A resin whose polymerization is initiated by a chemical activator.

Bead-brush technique: A method of applying an auto polymerizing resin mix to a surface whereby a brush tip is first dipped in liquid monomer and then polymer powder forming a small bead that is incrementally applied to form the desired shape.

Bench set: A stage of resin processing that allows a chemical reaction to occur under the conditions present in the ambient environment; also used to describe the continuing polymerization of impression materials beyond the manufacture's stated set time.

Bisphenol-A glycidyl dimethacrylate: A high molecular weight resin constituent of most dental composite resins.

Block out: Elimination of undesirable undercuts on a cast, 2: the process of applying wax or another similar temporary substance to undercut portions of a cast so as to leave only those undercuts essential to the planned construction of prosthesis. A blocked out cast may also include other surface modifications needed relative to the construction of the prosthesis.

Cast: To produce a shape by thrusting a molten liquid or plastic material into a mold possessing the desired shape.

Casting: Something that has been cast in a mold; an object formed by the solidification of a fluid that has been poured or injected into a mold.

Coping: A thin covering or crown.

Crucible: A vessel or container made of any refractory material (frequently porcelain) used for melting or calcining any substance that requires a high degree of heat.

Crown: The highest part, as the topmost part of the skull, head or tooth; the summit; that portion of a tooth occlusal to the dentinoenamel junction or an artificial substitute for this 2: an artificial replacement that restores missing tooth structure by surrounding part or all of the remaining structure with a material such as cast metal, porcelain, or a combination of materials such as metal and porcelain.

Cyanoacrylate : A single component, moisture activated, thermoplastic group of adhesives characterized by rapid polymerization and excellent bond strength.

Custom tray: An individualized impression tray made from a cast recovered from a preliminary impression. It is used in making a final impression.

Die: The positive reproduction of the form of a prepared tooth in any suitable substance.

Die spacer: An agent applied to a die to provide space for the luting agent in the finished casting.

Divest: The retrieval of a casting or prosthesis from an investing medium.

Dimensional stability: The ability of a material to retain its size and form.

Fit: To be suitable or to be in harmony with 2a: to conform correctly to the shape or size of 2b: to insert or adjust until correctly in place; to make or adjust to the correct size or shape, i.e., to adapt one structure to another, as the adaptation of any dental restoration to its site, in the mouth.

Impression material: Any substance or combination of substances used for making an impression or negative reproduction.

Intaglio surface: The portion of the denture or other restoration surface that has its contour determined by the impression; the interior or reversal surface of an object.

Jig: A device used to maintain mechanically the correct positional relationship between a piece of work and a tool or between components during assembly or alteration.

Investing: The process of covering or enveloping, wholly or in part, an object such as a denture, tooth, wax form, crown, etc. with a suitable investment material before processing, soldering, or casting.

Lost-wax casting technique: The casting of a metal into a mold produced by surrounding (investing) an expendable (wax) pattern with a refractory slurry that sets at room temperature, after which the pattern is removed through the use of heat.

Margin: the outer edge of a crown, inlay, onlay, or other restoration. The boundary surface of a tooth preparation and/or restoration is termed the finish line or finish curve.

Methyl methacrylate resin: A transparent, thermoplastic acrylic resin that is used in dentistry by mixing liquid methyl methacrylate monomer with the polymer powder. The resultant mixture forms pliable plastic termed dough, which is packed into a mold prior to initiation of polymerization.

Metal ceramic restoration: A tooth or/and implant retained fixed dental prosthesis that uses a metal substructure upon which a ceramic veneer is fused.

Monomer: A chemical compound that can undergo polymerization; any molecule that can be bound to a similar molecule to form a polymer.

Nickel-chromium alloy: A low density, large grained base metal dental casting alloy with prominent dendritic structure, composed of up to 30% Cr and 70% Ni with trace elements that may include small amounts of Mo, Mn, Si, C, and Al. Chromium, by its passivation effect insures corrosion resistance of the alloy. Increased nickel content tends to result in reduced strength, hardness, modulus of elasticity and fusion temperature while ductility may increase.

Pattern: A form that is used to make a mold; a model for making a mold.

Polymer: A chemical compound consisting of large organic molecules built by repetition of smaller monomer units.

Polymerization: The forming of a compound by the joining together of molecules of small molecular weights into a compound of large molecular weight.

Polymerize: To effect a chemical reaction by joining together individual molecules to form large molecules made up of many repeated units.

Poly(methyl methacrylate): A stable, hard transparent resin of marked clarity with a Knoop hardness number ranging from 18-20, a tensile strength of approximately 60 MPa, a density of 1.19 and a modulus of elasticity of approximately 2.4 GPa.

Porosity: The presence of voids or pores within a structure 2: the state or quality of having minute pores, openings or interstices.

Resin: any of various solid or semisolid amorphous natural organic substances that usually are transparent or translucent and brown to yellow; usually formed in plant secretions; are soluble in organic solvents but not water; are used chiefly in varnishes, inks, plastics, and medicine; and are found in many dental impression materials 2: a broad term used to describe natural or synthetic substances that form plastic materials after polymerization. They are named according to their chemical composition, physical structure, and means for activation of polymerization.

Sprue: the channel or hole through which plastic or metal is poured or cast into a gate or reservoir and then into a mold 2: the cast metal or plastic that connects a casting to the residual sprue button.

Thermal expansion: Expansion of a material caused by heat.

Undercut: The portion of the surface of an object that is below the height of contour in relationship to the path of placement 2: the contour of a cross-sectional portion of a residual ridge or dental arch that prevents the insertion of a dental prosthesis 3: any irregularity in the wall of a prepared tooth that prevents the withdrawal or seating of a wax pattern or casting.

Wax: one of several esters of fatty acids with higher alcohols, usually monohydric alcohols. Dental waxes are combinations of various types of waxes compounded to provide desired physical properties.

Wax elimination: The removal of wax from a mold, usually by heat.

Wax expansion: A method of expanding a wax pattern to compensate for the shrinkage of gold during the casting process.

Wax pattern: A wax form that is the positive likeness of an object to be fabricated.

INTRODUCTION

A restoration can survive in the biological environment of the oral cavity only if the margins are closely adapted to the cavosurface finish lines of the preparations. Improper marginal fit has been identified as one of the causes of failure of cast restorations. Incomplete marginal adaptation has been associated with the development of secondary caries and gingival inflammation. The metal coping is an important part of the metal-ceramic restoration, and one that unfortunately is often overlooked[1]. The ability to fabricate precisely fitting castings and to reproduce them time and again has been the principal objective of many investigators.[2]

Different materials and different techniques have been used to fabricate dimensionally stable copings. From early 1900s studies have been reported in literature about the composition, properties and uses of dental waxes. Maves in 1932 and Lasater in 1940 experimented with the distortion of wax patterns. It has been concluded that waxes are sufficiently stable materials if handled properly[3]. It has been reported that in inlay wax most of the distortion occurred during the first 2 to 3 hours of storage, and if storage of the pattern was necessary, a low temperature would reduce the degree of distortion[4].

As inlay wax distortion is time dependent it should be invested immediately, within 30 minutes[4]. But this is not possible if we are constructing wax patterns for full mouth rehabilitation or for more complex cases, and remains as a practical problem.

A pattern should be completely rigid and dimensionally stable when it is removed from the die[5], which is not possible with inlay wax. Some physical properties are critical for the wax to be acceptable. As an alternative, Autopolymerizing resin as a pattern material was first described in the 1950's by saunders. [6]. Autopolymerising resins offer strength, rigidity and dimensional stability even if immediate investing of the pattern is not possible. After setting, Autopolymerizing resins can be easily trimmed with rotary instruments with no fear of distortion.[7] However, the main disadvantage of this material is the marginal discrepancy which may increase in these resins due to their high polymerisation shrinkage which can occur within few hours during its complete polymerisation and the inability to control the powder: liquid ratio.[8]

To overcome this problem, photopolymerising materials were introduced in the laboratories to make copings. They provide many benefits, including faster and complete curing; reduced porosity as mixing was generally not required, almost instant finishing and adequate working time for complex procedures.[9]

Even though there exist many benefits with photopolymerising resins, these too are resins and so can undergo 'polymerisation shrinkage', but, may be at a reduced level. But with photopolymerising resins there is a phenomenon called 'post-polymerisation'[10] which occurs due to presence of free radicals during the first 24 hours.

Thereby both resins and pattern waxes undergo distortion within the first 24 hours. The pattern waxes undergo distortion which is mainly depended on storage time and temperature, whereas resins undergo distortion within the first 24 hours because of polymerisation shrinkage of the material.

The room temperature[11] of 23^0c, as specified by manufacturers of these pattern materials are not suitable for tropical countries like India, where the atmospheric temperature is usually much higher than 35^0c. Hence, the temperature can also influence the material properties during working and/or storage.

But, there are only few studies reported in literature by comparing these three types of materials by their storage time and temperature.

Hence, the purpose of the study was to know whether storage time and temperature influenced the marginal accuracy between commercially available Inlay wax, Autopolymerized pattern resin and light polymerized pattern resin, which were fabricated using the lost wax technique.

STATEMENT OF PROBLEM

A dental crown, serves as a retainer to replace a/many teeth, to strengthen a tooth and maintain its integrity after it has suffered destruction, either from tooth decay or from a trauma[1]. The most common failure of the abutment is secondary caries which is due to marginal leakage. Therefore precise marginal seating is more important in dental restorations to fulfill biological, physical, esthetic and long term success in oral cavity.[12]

Technical errors can be greatly reduced by strictly adhering to certain fundamentals, but the property of materials used for fabrication of patterns can still influence the fit of the castings. Traditionally, patterns were fabricated in type II inlay waxes by using indirect waxing technique[9]. Inlay pattern wax has a high coefficient of expansion and tends to warp or distort when allowed to stand unrestrained. The distortion is increased generally as the temperature and time of storage are increased. Distortion of wax patterns are created due to the release of internal stresses which occurs during manipulation. Ideally wax patterns should be invested immediately, but it may not be practically possible, every time. [9]

To overcome these disadvantages pattern resin materials have been introduced. Pattern resins were available as Autopolymerizing and light cured resins. Autopolymerising resins provide reduced time for manipulation, but provide rigidity and hardness to allow contouring to be performed with abrasive instruments.[13]

To overcome the drawbacks of these materials, light cured pattern resins were introduced which have better fit and stability after polymerisation. The advantages are low polymerisation shrinkage, adequate dimensional stability, ease of manipulation, reduced chair time and absence of residue on burn-out. Even though pattern resins are more dimensionally stable than waxes they also have an effect on the accuracy, because of storage time and temperature.[13]

Very few studies have been conducted to evaluate and compare the marginal accuracy and the effect of storage time and temperature on different pattern materials which are available in the market. Hence this study was proposed to find a material which could be used for fabrication of a pattern, which could give good marginal accuracy on storage at different temperatures, when they cannot be invested immediately.

AIM AND OBJECTIVES

AIM OF THE STUDY

The aim of this study was to compare the Marginal accuracy between commercially available inlay wax, Autopolymerising pattern resin, and light cure pattern resin material before and after fabrication of castings.

OBJECTIVES OF THE STUDY:

Primary:

The primary objective of the study was,

- To compare the marginal accuracy between copings fabricated by using commercially available inlay wax, Autopolymerising pattern resin and light cure pattern resin, which were invested and cast immediately.

Secondary:

The secondary objectives of the study were,

- To evaluate the effect of storage temperature and time on marginal accuracy between commercially available inlay wax, Autopolymerising pattern resin and light cure pattern resin.

-To evaluate and compare the effect of storage temperature and time on marginal accuracy between commercially available inlay wax, Autopolymerizing pattern resin and light cure pattern resin before fabrication of castings.

-To evaluate the effect of storage temperature and time on marginal accuracy between commercially available inlay wax, Autopolymerising pattern resin and light cure pattern resin after fabrication of castings.

NULL HYPOTHESIS

1. There is no significant difference in marginal accuracy between commercially available inlay wax, Autopolymerising pattern resin and light cure pattern resin, when cast immediately.
2. There is no significant difference in marginal accuracy between commercially available inlay wax, Autopolymerizing pattern resin and light cure pattern resin because of storage temperature and time

REVIEW OF LITERATURE

- **Gibbs et al,(2014)[36]** In this article, the authors had done a comparative study about polymerisation shrinkage for pattern resins like Duralay, GC (Autopolymerising resins) and primopattern LC Gel and paste (Photopolymerising).It was concluded that, primopattern LC paste had higher polymerisation shrinkage compared to other pattern resins. But there was no significant difference between primopattern LC gel, Duralay and GC pattern resins because all of their main constitutions were acrylic resins.
- **Phillips RW et al, (1950)[4]** In this article, the authors have done a study about distortion of wax patterns under the influence of storage time, temperature and temperature of wax manipulation .They concluded that, if distortion has to be prevented, the pattern must be invested immediately. Most of the distortion occured during the first 2 to 3 hours after fabrication. If the temperature of the wax during manipulation was higher, it caused lesser strain and so lesser distortion. When wax was subjected to non-uniform patching and pooling it increased the distortion. The theoretical point, they stated for distortion was the release of internal strain of wax patterns during storage. The longer the wax patterns were stored, the greater was the release of strain. Rise in temperature raised the flow and lowered the yield point of wax. The release of internal strain was accelerated by increase in storage temperature.
- **Sushma R et al, (2014)[12]** In this article, the authors have done a study about vertical marginal discrepancies of metal copings using inlay wax, Autopolymerising and light cure pattern resin. The study concluded that, if immediate investment and casting can be

performed the material of choice for making patterns will be inlay wax which is also economical and less technique sensitive.

- **Katta Sridhar Chowdary et al, (2011)**[42] In this article, the authors had done a study about marginal fit of castings made with nickel chromium and cobalt chromium alloys using varying coats of die spacers. The average thickness of single layer of spacer coating was 20 microns. The study concluded that minimum discrepancy was found when three coatings of spacer were applied when using nickel-chromium alloys. The cobalt chromium alloys showed higher marginal discrepancy than nickel chromium alloys and the discrepancy increased when the number of coating were increased.
- **Abhishek Rastogi et al,(2011)**[31] **In** this article, the authors had done a comparative analysis of the different methods used in evaluation of marginal accuracy of cast restorations. They compared three methods like, evaluating with explorer, fit checker paste and stereomicroscope. It was concluded that, commonly used clinical evaluation techniques i.e explorer and elastomeric disclosing media may be inadequate for assessment. For better evaluation, the routine use of stereomicroscope in the laboratory is indicated which provides a superior quality control prior to examination of restorations intraorally.
- **A.J.Hunter et al,(1990)**[30] This article, reviews about gingival margins for crowns. It states that, supragingival margins will preserve the periodontium and that beveling can reduce the discrepancy. Among beveling, a low angle and or a lengthy bevel may have less marginal discrepancy when compared to high angle and a short bevel. But horizontal margins like shoulder can constantly cause more predictable but less marginal discrepancy**.**

- **Noor A.Nawafleh et al,(2013)**[40] This article reviews about, accuracy and reliability of methods to measure marginal adaptation of crowns and fixed partial denture's. The parameters that have an influence are sample size, method of measurement and type of finish line. Among method of measurement, the direct view method showed high reliability than other methods. Under the influence of sample size, when investigating the marginal fit of fixed dental restorations, the smaller sample size (n=10) can be compensated by a large number of measurements per sample (50 measurements) and under the influence of finish line, a shoulder finish line showed more approximation of marginal gap when compared to others.

- **Ghanbarzadeh et al,(2007)**[45] In this article, the authors had done a study to evaluate the effect of storage time and conditions of dimensional stability of duralay acrylic resins for post and core patterns. They divided the samples into 3 groups. The First group was stored in dry atmosphere at 25°c, second group samples were stored in 100% humidity at 25°c and third group were stored in water and placed in refrigerator at 4°c.All the samples were stored for 24 hours. The study concluded that, the best condition for storing duralay post and core pattern was 100% humidity at 25° c for 24 hours.
- **Mohammed aleem Abdullah et al, (2005)**[6] this article, explains a study about the effect of storage time on marginal accuracy of full coverage crowns made by using different pattern materials like wax, Autopolymerizing (duralay resin) and Traid VLC (light cure resin).The study concluded that, all patterns showed continued shrinkage after storage at room temperature and in that wax showed the highest marginal discrepancy and Autopolymerizing resin the least, with visible light cured acrylic resin in between.

- **Junzo Takahashi et al, (1999)**[43] In this article, the author has done a study to find a new additive for GC pattern resin material which reduces polymerisation shrinkage. To find this, they had used 3 methods of specimen preparation like injection, injection –press method, and brush on technique, 4 different powder liquid ratios like 2.25:1.00,2.00:1.00,1.75:1.00,1.50:1.00, and 3 chemical additives like (1) a coumarone indene resin, (2) An acryloyl morpholine and (3) an oxocol to liquid. The study concluded that, the injection –press method and the brush on method gave the lowest polymerisation shrinkage. The polymerisation shrinkage reduced with increase in the P:L ratio. All 3 additives reduced the polymerisation shrinkage to about 1/3 of the shrinkage of the basic resin.
- **Philippe Mojon et al, (1990)**[43] This article, evaluated the dimensional change of resins used for indexes and patterns ,analyzed the influence of powder to liquid ratio on dimensional change and compared 2 products available in the market (palavit G, Duralay).The study concluded that, palavit G and duralay have shrinkage of 6.5% and 7.9% respectively. Eighty percentage of dimensional change occured before 17 minutes, 95% before 3 hours for duralay and 2 hours for palavit G resins. Between 24 hours and 30 hours changes continued but their values were close. No measureable change occurred after 30 hours. Altering the powder to liquid ratio by adding more liquid significantly increased the shrinkage.

- **Praveen Rajagopal et al,(2012)**[9] This article, compared the accuracy of patterns processed from an inlay casting wax (Gc),Autopolymerizing resin (Gc) and light cured resin pattern material (palavit GLC) .The patterns were stored in room temperature and checked at the interval of 1 hr,12 hr, and 24 hrs. At 1 hr, Autopolymerizing resin showed higher marginal discrepancy due to polymerisation shrinkage. Inlay wax showed highest discrepancy over 12 and 24 hr interval due to its tendency to warp or distort and high coefficient of thermal expansion. The conclusion of the study was, that the resin pattern materials underwent significantly less dimensional change than the inlay waxes on prolonged storage. Hence, it is advisable to use them in preference to inlay wax in situations requiring high precision or when delayed investment (more than 1 hr) of patterns can be expected.

- **Sheikh SA et al, (2014)**[5] The author has evaluated the marginal accuracy and internal adaptation for complete cast crowns produced through inlay wax, light cure wax (LIWA wax) and pattern resin (GC).The study concluded that inlay wax had better marginal accuracy than Liwa wax and GC,as inlay wax (400 ppm/K) had a higher co-efficient of thermal expansion compared to resin (81ppm/K) which would provide a bigger mold space due to more expansion of wax during the setting of the investment, slightly bigger castings are obtained with better adaptation.
- **Alan Iglesias, MS et al, (1996)**[13]The author has done a study to evaluate the accuracy of wax, autopolymerized and light polymerized resin pattern materials for full crown and MOD inlay dies. The patterns were prepared with 2 light polymerized, Diacrylate resins (Palavit GLC,Traid VLC),inlay wax (Kerr) and an autopolymerized acrylic resin (Duralay) using incremental and bulk technique. The study concluded that, the light-polymerized, diacrylate resins had equal or better marginal fit compared with wax or

autopolymerized resin, and were less affected by placement technique and storage .All patterns produced clinically acceptable discrepancy.

- **J.Robert Holmes et al, (1989)**[39] In his article has explained about various terminologies about marginal fit like internal gap, marginal gap, vertical marginal gap, horizontal marginal gap, overextended gap, underextended gap and absolute marginal gap. They concluded that although standardization of misfit measurement is probably not possible, clarification of terminology is necessary for consistency.
- **J.M. Whitworth et al, (1999)**[48] has done a study about the curing depth and polymerization shrinkage of three different light activated pattern materials like lumin X paste, visioform, and lumin-X gel. The curing depth is increased for visioform compared to lumin products as they had a higher proportion of wax which will reduce the strength of penetration of light. But polymerization contraction was lower for lumin products because of the nature of fillers or due to low conversion after curing .The conclusion of the study was that light –activated pattern resin may be built up incrementally in a comparable manner to composite resins.
- **Martin Groten et al, (2000)**[37] In his article, tried to find out the minimum number of measurements needed to find the marginal gap with the help of statistical values. They concluded that if minimum 50 measurement sites per crown can yield clinically relevant information which is independent of whether the crowns were cemented or uncemented, sites were randomly selected or spaced with 500 µm each other.
- **Yasunori Suzuki et al,(2009)**[46] In this article, the author has done a study to find the handling efficiency of 5 different types of resins (unifast II, unifast triad, provinice, metafast, and milky) and 4 different brushes (calligraphy, horse hair, nylon and

weasel).They concluded that the handling efficiency of the autopolymerized resins using the brush-on technique depended on the skill of the operators rather than the kinds of resins and brushes. Although the effect of the autopolymerized resins on the handling apparently could not be found, the calligraphy brush indicated superior handling efficiency.

- **Erica F. Moray et al,(1991)[33]** This article, elaborates about the history of evolution of casting method and materials ,the behavior of inlay wax and how it is compensated by the investment and has also explained about the distortion of wax patterns.
- **Randa Diwan et al,(1997)[32]** In this article, the author describes about the classification of pattern waxes and their physical properties, which causes inaccuracies during and after casting.
- **Knud Dreyer Jorgensensen et al, (1983)[47]** In this article, the author has done a study about distortion of wax crowns. They compared, whether there is difference between different commercially available materials(Kerr type I, II, Shofu type II wax), method of fabrication(pour –press type method, melting method) and different storage time of materials (0,10,60,1440 minutes). They concluded that, inlay wax because of the inherent property of distortion is an inadequate material for pattern in a full crown technique with high requirements as to precision.
- **Shigeru Hanatani et al,(2009)[35]** This study is about the dimensional accuracy of 5 different Autopolymerizing resins like unifast II (Gc), unifast triad(Gc), provinice (shofu), metafast(sun medical) and milky (nissin) using brush on technique. They had used control specimens which were prepared through conventional mixing technique. They concluded that brush on technique showed more dimensionally stable specimens

compared to conventional mixing technique because of lower L/P ratio needed for brush on technique which lead to lesser polymerization shrinkage.

- **R.G.Craig et al,(1988)[38]** This article, describes about the properties of different impression materials like impression compound, zinc oxide eugenol, hydrocolloid impression materials, rubber impression materials and their compatibility with gypsum products, effect of trays and effect of techniques.
- **E.S.Smyd et al, (1948)[49]** This article describes about factors which influence casting accuracy. The shrinkage of wax and gold alloys should be compensated by three methods namely wax expansion, controlled mold expansion (thermal, setting expansion) and hygroscopic expansion. Hence, by controlling the various factors which produce distortion, the restoration requires no or minimal modification during clinical procedures.
- **Gholamreza Danesh et al, (2004)[50]** This article compares the polymerisation characteristics of light activated resins like (Acrylight,primosplint,traid tran sheet colourless and pink) and an Autopolymerizing resin (palapress).The polymerisation shrinkage and volumetric shrinkage can be influenced by the filler content and initiator system used in their resins.
- **Anshul chugh et al, (2012)[15]** In this article, the author has done a study about the accuracy of stone casts obtained from different putty wash impression techniques using 1 and 2 mm spacer thickness, polyethylene sheet as spacer, and one step technique as control. The results concluded that 1 and 2 mm uniform spacer thickness produced clinically acceptable range. The usage of polyethene spacer was discouraged. The author suggests that, make temporary acrylic crowns could be used to achieve a more controlled wash space, clinically.

- **Dheeraj kumar et al,(2011)**[17] In this article, the authors have done a study about comparison of dimensional accuracy of multiple pours for elastomeric impression materials like polyether,addition silicone,condensation silicone and monophase addition silicone. The author concluded that, none of the impression materials showed a consistent behavior upto fourth pour, but they were statistically insignificant .Among them, polyether showed lesser ability to recover from permanent deformation than both addition silicone and condensation silicone**.**
- **Goodacre et al, (2001)**[14] The article reviews about principles and guidelines for complete coverage tooth preparations. According to the result, the prepared teeth should exhibit 10 to 20 degrees of total occlusal convergence, a minimal occlusocervical dimension of 3mm other than molars and an occlusocervical to faciolingual dimension ratio of 0.4 or greater.
- **Edward J.Plekavich et al, (1983)**[51] This study compares the effect of impression material (polysulphide,polyether,silicone) and die system (improved stone,electroplated silver die)on crown margins. The mean vertical marginal opening of silver dies to silicone impression was 64.7µm and for stone dies to silicone impressions were 114.3µm. Among silicone impression, polysulphide with silver dies produced least marginal opening (vertical defect).
- **Mahmoud sabouhi et al,(2015)**[52] This article describes a study about the effect of time and storage environment on dimensional changes of acrylic resin post patterns. The samples were stored in water, air, Naocl 5% and measurements were made at immediately after polymerisation, 1, 2, 4,8,24 and 48 hour later. For this study duralay

pattern resin was used and results concluded that the acrylic resin patterns can be stored in water for 8 hours and 2 hours in air environment after setting time.

- **Barry Marshak et al, (1990)**[18] In this article, the author describes about errors that can occur during impression making using putty wash technique and how to compensate by using a provisional restoration.
- **Michio Ito et al, (1996)[53]** In this study, the author has evaluated the relationship between flow characteristics, bending strength and softening temperature of dental inlay waxes to casting shrinkage when invested in phosphate bonded investment. The results concluded that, the casting shrinkage decreased as the flow of the wax pattern increased. If a low flow wax is used or if there is a need for a thick pattern, the size of the casting ring should be increased.
- **David Ehrenberg et al, (2006)[54]** In this article, the author examined the effect of long term water absorption and thermal cycling on marginal gap size of polymethyl methacrylate co polymers and bis acrylic composite resin crowns. Acrylic resin crowns are observed to contain voids, encounter polymerisation stresses, retain residual unreacted monomer, and demonstrate crack propagation from thermal and occlusal stresses transmitted to the marginal area. The provisional crowns which were stored in the humidor showed a mean marginal opening of 323.2 ±87.8µm.
- **Habib H. Ghahremannezhad et al,(1983)**[22] This article deals with a study about the effect of cyanoacylates on die stone. The results of this study showed that the application of one coat of cyanoacrylate resin on the surface of type IV dental stone followed by removal of the excess resin by a blast of air resulted in (1) increase in surface hardness by

about 150%.(2) increase in the stone's resistance to scratch by sharp instruments by 48% (3) closing of the pores and production of a shiny surface.

- **Delphine Truffier-Boutry et al,(2006)[10]** The author has done a study about post polymerisation shrinkage in dental resins, 24 hours after photopolymerisation. The acrylic resins undergo relaxation to reach a more stable state by losing excess of free volume which could cause "post shrinkage".
- **Techkouhie A. hamalian et al,(2011)**[16] This article reviews about different properties of elastomeric impression materials and the efficiency of each impression material. As a result, the authors stated that polyvinylsiloxane had the best fine detail reproduction and elastic recovery of all available materials and thus is the impression material of choice for fixed prosthesis. The only disadvantage is their hydrophobic nature which has been altered and made hydrophilic, but still they are suggested to used under dry conditions.
- **Mohammed Aleem Abdullah et al,(1998)[21]**The author conducted a study about void formation in dies poured from polyvinyl siloxane impression by the effect of frequency and amplitude. The results stated that if frequency is set to 6000 cycles/min and o.40mm of amplitude (step 3) of vibration caused minimal voids.
- **Apostolos Al.krikos et al ,(1968)[55]** In this article, the author had explained about the usage of cold cure resin for construction of patterns. Resins can also be used, where the preparations are not parallel to each other, when undercut is present in the preparation and when a try in required.
- **Anna Belsuzarri olivera et al,(2006)[24]**.In this article, the author explains about the effect of die spacer on retention and marginal fit of complete cast crown dies covered with four layers of die spacer using three techniques(1) covering the occlusal and 1/3 of

the axial surfaces, (2) covering the occlusal and 2/3 of the axial surfaces.(3) covering the entire preparation except the apical 0.5mm of the preparation. And the results concluded that before cementation, better marginal fit was obtained when the die spacer covered all but the area 0.5mm short of the margin of the preparation.

- **Eleni kotsiomiti et al, (1994)**[3] In this article, the author conducted a study to compare the commercially available waxes about their flow, linear thermal expansion and whether they were correlating with the ADA specifications. There was an increase in flow by increasing the temperature upto solid-solid transition point. This phenomenon, which corresponds to the softening of the materials, was observed at approximately 42^{o}c for pattern waxes.
- **E.M.Ness et al,(1992)**[56] This article deals with the accuracy of fit of dental acrylic pattern resins (duralay, Gc pattern resin and relate) to implant abutments, used for an implant retained prosthesis. Dental acrylic resins exhibit shrinkage upon polymerisation. The manufacturers of these products gave linear shrinkage values that ranged between 0.67% and 0.78% setting shrinkage after a 24 hour period. The authors concluded that relate acrylic resin exhibited least variability of the three resins tested.
- **Ivy S.Schwartz et al, (1986)**[34] In this review article, the author has enumerated different methods and techniques to improve the fit of cast restorations. The internal relief of wax by application of a die spacer to the die before fabrication of wax patterns is one of the methods to improve seating. The use of a die spacer is founded primarily on the concept that a uniform and specific amount of space between the tooth and casting allows the cement to escape and decreases hydrostatic pressure. The amount of relief suggested is in

the range of 20 to 40 µm.ADA specification No.8 for zinc phosphate cement allows for 25 µm cement film thickness, the die spacer thickness used by most investigators.

- **John .A. Sorenson et al, (1990)**[57] In this article, the author has used a different method to determine the marginal opening using photographs. By using this method, the interobserver variance was 10 µm for the horizontal and 9 µm for the vertical marginal discrepancy.

MATERIALS

Materials

- Custom made master die made of Austenitic 304 stainless steel (fig 2 and 3)
- Perforated custom made impression trays- made of Austenitic 304 stainless steel (fig 5)
- Poly vinyl siloxane putty and light body impression material-Aquasil, Dentsply, India.(fig 7)
- Type IV gypsum product – Ultrarock; Kalabhai,Karson Pvt ltd,India (fig 11)
- Yeti Die Hardener- Yeti dental products,Germany (fig 12)
- Yeti Die Spacer (Red)- Yeti Dental products,Germany (fig 13)
- Yeti Die Lubricant – Yeti Dental Products,Germany (fig 14)
- Coping wax-Duo dip, yeti dental products, Germany.(fig 19)
- Gc Autopolymerizing resin Kit(fig 22)
- Primopattern LC Gel, Primotec, Bad Homberg (fig 23)
- Investment material – metavest Germany(fig 28)
- Sprue wax- Duron,Yeti Dental Products,Germany
- Surfactant-unicoat Debubblizer,Delta,chennai
- Die pins(Delta,Chennai)
- Self cure material (DPI,mumbai)
- Ni-Cr alloy -4all Ivoclar vivadent

Devices

- DMLS machine; EOSINT M 270, EOS, Munich,GmbH.
- Vacuum Mixer ; Tornado – 804S,Silfradent,Forli,Italy (fig 9)
- Vibrator,VIB-15,Silfradent,Forli,Italy.(fig 10)
- Wax Pot- Delta, Chennai, India.(fig 18)
- Light curing chamber,Delta,Chennai,India (fig 40)
- Optical stereomicroscope- MAGNUS MSZ-TR,Magnus Analytics(fig 25)
- Burn out Furnace, Midtherm 100 (fig 30)
- Induction casting machine- Fornax T,Bego (fig 29)
- Sand blaster, Ideal Blaster, Delta, Chennai (fig 32)
- Refrigerator,LG butterfly.
- Vacuum forming machine, Delta,Chennai,India.
- Lab Micromotor with Handpiece (fig 33)
- Alloy Grinder –Ray Foster (fig 35)
- Lighted Magnifying lens, vertex,chennai (fig 21)

Armamentarium

- PKT instrument (Fig 20)
- Vacuum formed Polypropylene sheet
- Plaster cutter (fig 31)
- Aluminium oxide powder
- Carborandum disk

- No.1 round bur
- Rubber bowl and spatula
- Applicator Brush
- Dappen dish
- B.P.Blade & handle
- Scissors
- Casting ring
- Crucible former
- Lecron’s carver
- Acrylic mixing jar

METHODOLOGY

Fabrication of the master die (fig no: 1, 2, and 3)

A standardized stainless steel die was used for the fabrication of copings. The dimensions of the master die was as follows; occluso cervical height of 4mm, diameter of 7mm, 8 degree occlusally converging taper, and a shoulder finish line[14] with a width of 2 mm .The master metal die was marked with 50 indentations which were placed approximately 1mm below the cervical preparation line[6]. These indentations were placed to help during measurement of gap, before and after casting. The master die had a base to support the coronal portion of the die. Two slots were prepared on the upper surface of the base, opposite to each other. The slots were placed to help in orientation of the custom made metallic and plastic templates.

Fabrication of master coping (fig no: 4)

A metal master die was scanned and a master coping was sintered through direct metal laser sintering technique. The master coping had a uniform covering thickness of 0.3mm around the coronal portion of the master die, including the margin, as shown in the figure (4).

Fabrication of custom made metallic impression tray (fig no: 5)

Tube shaped, perforated (escape ways for excess material) custom made metallic impression trays (6 nos) were fabricated. The inner diameter of the impression tray was 20 mm and the height was 25 mm. This specific dimension for the impression tray was followed so as to provide a uniform space for the impression material. One side of the impression tray was closed with a square shaped stainless steel plate. By using these trays the impressions were made with polyvinyl siloxane putty and light body impression material.

Fabrication of a custom acrylic spacer (space for light body) (fig no: 6)

A required amount of polymer and monomer of polymethyl metha acrylate was mixed in a dappen dish to fabricate a custom acrylic spacer. The acrylic spacer was trimmed and polished to a uniform thickness of 1mm[15] and it covered the coronal portions of the master die, including the margin area. When making an impression with putty it was placed over the master die to provide uniform space for the light body.

Fabrication of custom made metallic template (for fabricating specimens of inlay wax and autopolymerizing resin) (fig no : 37)

Block out was done in the undercut areas using block out wax, below the coronal portion of the master die to fabricate a metallic template. After block out, the master coping was placed over the master die and wax up was done to cover the entire die, except the base. The wax up was done to cover the orientation slots made on the base of the master die. A sprue wax was attached on the occlusal surface of the wax template which served as a handle in further steps of the study. The waxed template was invested and cast immediately. The intaglio surface of the metallic template was only polished to reduce the dimensional change after casting. Inlay wax and Autopolymerizing resin specimens were fabricated with the help of this custom made metallic template.

Fabrication of custom vacuum formed plastic template (For fabricating specimens of light cure Resin) (fig no :24)

A metallic template will not allow halogen light to penetrate and polymerize the photopolymerising resin. So, a transparent template was fabricated to allow light to pass inside it. A sample die was placed onto the stage of the vacuum former after blocking out the undercuts below the coronal portion with plaster; a clear polypropylene plastic sheet was placed into the holder of the vacuum former. The application of heat softened the plastic sheet. The upper arm which held the sheet was pressed over the die. A vacuum was formed which sucked the softened plastic sheet towards the die. A scissors was used to trim the excess after the plastic sheet hardened.

Fabrication of custom made acrylic jig: (fig no:27)

To control the direction and magnitude of force applied, construction of an acrylic jig was done. In the jig the direction of closure was consistent and after complete closure the flat inner surface of the jig and the flat occlusal surface of the coping were always in contact which prevented its tipping.

The jig consists of three parts an upper arm, lower arm and a middle part which holds the specimen in position. The lower arm held the die while the upper arm applied pressure.

Construction of middle part of the jig:

The required amount of polymer and monomer was mixed in a mixing cup; the dough was flattened over a glass plate. A thin coat of Vaseline was applied on the master die and was embedded half the horizontal length into the mix, so that it would not create an undercut and get locked out.

Construction of upper and lower arm:

Later, another mix was made to fabricate two bars that represent the upper and lower arms of the jig, respectively. After complete setting, two die pins(one on either side) were attached to the sides of the upper and middle part, which were perpendicular to the upper and middle part. Two die pins (one on the either side) were attached to the sides of the lower and middle part, which were perpendicular to the lower and middle part. Eight holes were drilled in total on the upper (two), middle (four) and lower part (two) and cyanoacrylate was used to attach sleeves into the holes. The three parts were then aligned by using the four pins into their respective sleeves.

Impression of master die:

An impression of the master die was made with addition silicone elastomeric impression[16] material, by using a two step putty wash impression technique[15]. Only two dies [17]were poured using one impression as it would maintain the accuracy .The two stage putty wash impression was made by first placing the 1mm acrylic spacer onto the die and then by making a putty impression by using the custom made impression tray[18]. The impression was removed after it was set and the spacer was removed to create space for the light bodied material. The wash impression of the master die was then made.

Impressions were poured after a 15 minute bench set.[19] The metal master die was cleaned every time with ethyl alcohol and distilled water and dried with paper towel before making each impression[6].

Pouring of impression with Die stone (fig no: 8)

Each impression was poured 2 times[17] with Class IV die stone by manually mixing[20] it by using a vibrator[21]. The die was separated from the impression after 1 hour. All dies were poured by the same operator to reduce the bias. The working dies were inspected for voids, and if present were excluded and replaced by another working die.

Application of Die Hardener:

A layer of die hardener [22]was coated over each specimen using Die hardener (YETI Dental products GmbH) .Excess material was removed with a blast of air using air syringe.

Application of Die spacer:

Die spacer (YETI Dental products, GmbH) was applied to the dies four times evenly[23]. Each layer was applied after observation of complete dryness of previously applied layer. The Die spacer was applied till 0.5 mm short of cervical margin of the dies.[24]

Application of Die lubricant:

Die lubricant (YETI Dental products GmbH) was applied to the dies according to the manufacturer’s instructions.

Grouping:

A Total of 90 specimens were fabricated, the dies were grouped according to the material used for fabrication of copings, further, according to the time and according to the temperature. They were grouped as,

Group I – Inlay wax (Duo Dip, yeti dental products, Germany)

Group II – Autopolymerising resin (Pattern resin LS, GC corp,America)

Group III – Photopolymerising resin (Primopattern LC gel, primotec, Bad Homberg)

G I c – Inlay wax, immediately invested and cast after fabrication.

G II c – Autopolymerising resin, immediately invested and cast after fabrication.

G III c – Photopolymerising resin, immediately invested and cast after fabrication.

Group I 2.a (b.c)- Inlay wax, stored at 0^0c, for 24 hours, measured before casting.

Group I 2.a (a.c)- Inlay wax, stored at 0^0c ,for 24 hours, measured after casting.

Group II 2.a (b.c)- Autopolymerising resin, stored at 0^0c, for 24 hours, measured before casting.

Group II 2.a (a.c)- Autopolymerising resin, stored at 0^0c,for 24 hours, measured after casting.

Group III 2.a (b.c)- Photopolymerising resin, stored at 0^0c, for 24 hours, measured before casting.

Group III 2.a (a.c) – Photopolymerising resin, stored at 0^0c, for 24 hours, measured after casting.

Group I 2.b (b.c)-Inlay wax, stored at ambient temperature, for 24 hours, measured before casting.

Group I 2.b (a.c)- Inlay wax, stored at ambient temperature, for 24 hours, measured after casting.

Group II 2.b (b.c) – Autopolymerising resin, stored at ambient temperature, for 24 hours, measured before casting.

Group II 2.b (a.c)- Autopolymerizing resin, stored at ambient temperature ,for 24 hours, measured after casting

Group III 2.b(b.c) – Photopolymerising resin, stored at ambient temperature, for 24 hours, measured before casting.

Group III 2.b (a.c)- Photopolymerising resin, stored at ambient temperature, for 24 hours, measured after casting.

The groupings were briefly tabulated in table.

<table>
<tr><td></td><td></td><td colspan="2">Inlay wax(yeti)
(GROUP-I)</td><td colspan="2">Autopolymerizing resin (GC)
(GROUP-II)</td><td colspan="2">Light cure resin (primopattern resin gel)
(GROUP-III)</td></tr>
<tr><td>Control
(immediately invested and cast after fabrication)</td><td></td><td colspan="2">10</td><td colspan="2">10</td><td colspan="2">10</td></tr>
<tr><td rowspan="4">after
24 hour
(2)</td><td rowspan="2">At 0^{o}c
(a)</td><td colspan="2">10</td><td colspan="2">10</td><td colspan="2">10</td></tr>
<tr><td>Group I 2.a (b.c)</td><td>Group I 2.a (a.c)</td><td>Group II 2.a (b.c)</td><td>Group II 2.a (a.c)</td><td>Group III 2.a (b.c)</td><td>Group III 2.a (a.c)</td></tr>
<tr><td rowspan="2">At ambient temperature
(b)</td><td colspan="2">10</td><td colspan="2">10</td><td colspan="2">10</td></tr>
<tr><td>Group I 2.b (b.c)</td><td>Group I 2.b (a.c)</td><td>Group II 2.b (b.c)</td><td>Group II 2.b (a.c)</td><td>Group III 2.b (b.c)</td><td>Group III 2.b (a.c)</td></tr>
<tr><td></td><td></td><td colspan="2">30</td><td colspan="2">30</td><td colspan="2">30</td></tr>
</table>

Fabrication of wax patterns:

In order to obtain an even thickness of the coping, a stainless steel metal custom template was fabricated with a uniform internal relief space of 0.3mm. To achieve uniform heating of wax during manipulation, coping wax (YETI Dental products, GmbH) was melted in a wax pot at a temperature of 120^{0} F. The wax was poured into the stainless steel metal custom template and placed over the die with finger pressure exactly orienting it to the slots on the base and held until it cooled to room temperature. The excess was carved and they were then approximated to the cervical margin of the stone die with the help of a magnification glass.

Investing the pattern:

In the control group, after checking and correcting the discrepancy at the margin, prefabricated sprues were attached to the occlusal surface of pattern copings. The sprues had a thickness of 2.5mm. The patterns were placed inside the casting ring by attaching them to the crucible former, by keeping them 6 mm away from the top of the casting ring. An X3 size silicone casting ring was used. Investing was done with Metavest –phosphate bonded investment. The manufacturer recommended a powder liquid ratio for metal castings and single crowns as 160g powder: 38 ml liquid and 4ml distilled water[26]. The measured quantity of liquid was taken in a clean mixing bowl and the pre weighed investment powder was added to it. The investment was mixed for 30 seconds manually[26] by a spatula and later it was attached to a vacuum mixer and mixed for 30 seconds.

The mixed investment was brushed onto the patterns and then poured into the ring with the help of a vibrator. The investment was kept aside for 30 minutes [26]allowing it to set completely.

Casting of the mold:

The investment was placed in a burn out furnace for pre heating and temperature was raised from room temperature to 250° c within 20 minutes. It was maintained at 290°C for 20 minutes, then raised upto 580°c and held for 20 minutes and again raised up to 900° c or 1650° F [26] and after reaching which, it was transferred to an induction casting machine. All castings were done using an induction casting machine.

Ni-cr base metal alloy was used for casting which was preheated in a ceramic crucible in the induction casting machine at 950°c. The melting range of alloy used in this study was 1260-

1350^{0}c. The casting was triggered at 1465 °c. [27]The investment with the Casting was allowed to cool down to room temperature gradually.

Divesting the investment:

The investment was wetted with water to avoid dust, while divesting. The investment was divested by using a plaster cutter. The residual investment was removed by sand blasting the castings with 110 micron Aluminium oxide particles[26]. Sprues were cut with the help of carborundum Separating disks using a high speed lathe and the castings were then seated on their respective dies. The intaglio surfaces of all castings were examined under a magnification glass and nodules were removed with a No .1 round bur using a lab micromotor.

The castings were seated on their respective dies using a custom made acrylic jig. The margins were then observed under a stereomicroscope and 5 digital images were obtained on each die .Later Measurements of the gap between the external margin of copings and the external cervical margin of the dies were made using image analyzer software (CMEIAS Ver.1.27 operating in UTHSCSA image Tool Ver 1.27).

Fabrication of Autopolymerizing resin patterns:

After application of lubricant on the die, the tip of the brush was moistened with liquid and then a small amount of powder was picked up and incrementally added on the die to build up the pattern[28]. To achieve an even thickness, the custom metal template was used by pressing it with finger pressure after orienting it to the slots on the base of the die .After 3 minutes[28] the resin copings on setting, were removed from the die and checked on the internal surface. If any fine adjustments were needed they were done with a bur attached to a micromotor. The patterns were sprued and invested as like the inlay wax patterns (control group). For pattern resins the burn out holding temperature was maintained at 250^0c for 1 hour[28]**.** Rest of the procedures followed were the same as for inlay wax patterns.

Fabrication of light cured resin patterns:

The light polymerizing gel was incrementally added onto the die after it was lubricated by applying it in a vibratory motion which helped to increase its flow. The copings were shaped to the uniform thickness by using a vacuum formed polypropylene matrix and light cured with a hand held halogen light for 30 seconds. After final shaping, the specimens were placed in a halogen light curing chamber, for 2 minutes[29].Rest of the procedures followed were the same as for autopolymerising resin.

Fabrication of patterns which were stored at 0^0c for 24 hrs:

After checking the approximation of margins of the patterns, the patterns with their respective dies were stored in a freezer and maintained at 0^0c for 24 hours. The temperature was checked by a room temperature thermometer.

Fabrication of patterns which were stored at ambient temperature for 24 hrs:

After checking the approximation of margins of the patterns, the patterns with their respective dies were stored in an incubator for 24 hours.

Measurements and castings of resin patterns after storage:

After storage at a particular temperature and time according to the grouping, the patterns were returned to room temperature by keeping the specimens outside for 8 minutes[7]. Each specimen was observed using an optical stereomicroscope. 5 digital images were made for each specimen and measurements were done using image analysis software. (CMEIAS Ver.1.27 operating in

UTHSCSA image Tool Ver 1.27). Rest of the procedures followed were the same as for inlay wax patterns.

Measurements for patterns (storage group) and copings (immediate cast, storage group) using image analysis software:

The measurements were made at 50 sites of each coping, 10 sites per digital image were made. From a total of 90 specimens, 750 digital images were obtained and a total of 7,500 measurements were made. The mean marginal discrepancy of each specimen was subjected to statistical analysis using SPSS software package for windows (ver .19.0 SPSS Inc.IBM Corp). Comparison of data was made using student independent t –test and ANOVA test with significance level of $p \leq 0.05$.

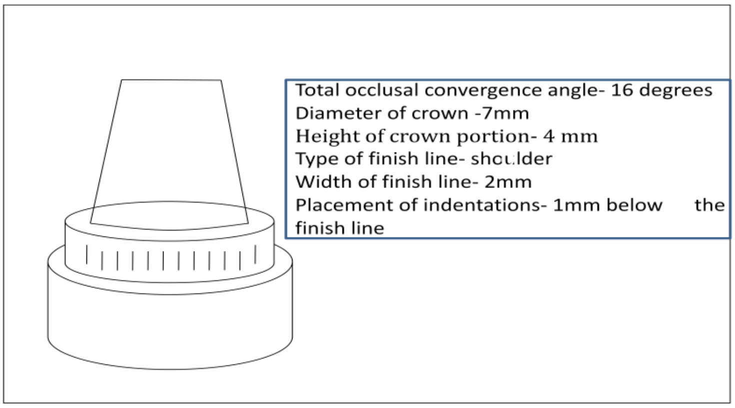


Fig No1: schematic diagram of master die

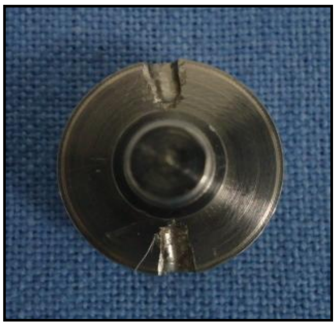


Fig No 2 : Master die with orientation slots-superior view

Fig No 3: Master die side view

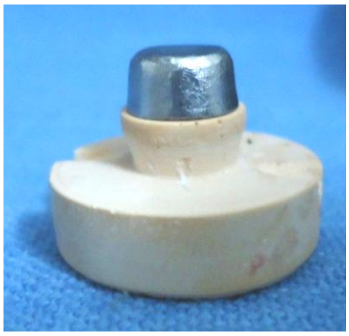


Fig No 4: DMLS- primary master coping on sample die.

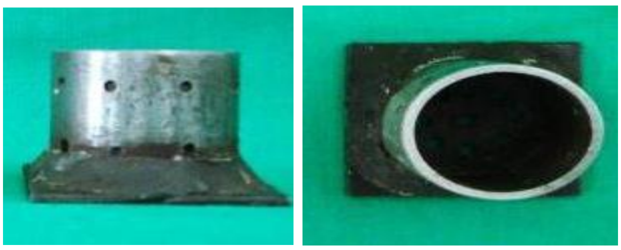


Fig No 5: custom made- stainless steel impression tray

Fig No 6 : Custom made- acrylic coping (spacer for light body)on master die

Fig no 7: Addition silicone impression material

Fig no 8: Impressions of master die with die stone poured in it.

Fig No 9: Vacuum mixer

Fig No 10: Vibrator

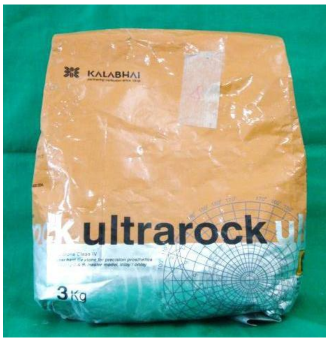


Fig No 11 : Type IV Gypsum product

Fig No 12,13,14: Die Harderner, Die Spacer, Die lubricant

Fig No 15, 16, 17: pattern Specimens for inlay wax, Autopolymerising resin, Light cure resin

Fig No 18: Wax pot filled with inlay wax

Fig No 19 : Inlay wax (yeti dental product)

Fig No 20: P.K.Thomas Instruments

Fig No 21: Magnification loop

Fig No 22: Pattern resin GC Autopolymerising kit

Fig No 23: Primopattern LC gel kit

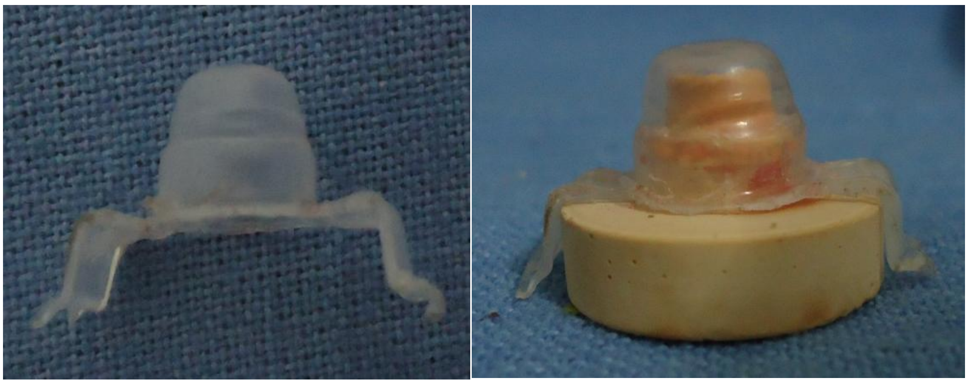


Fig No 24: custom made Vaccum formed plastic template used for fabrication of light cured resin patterns

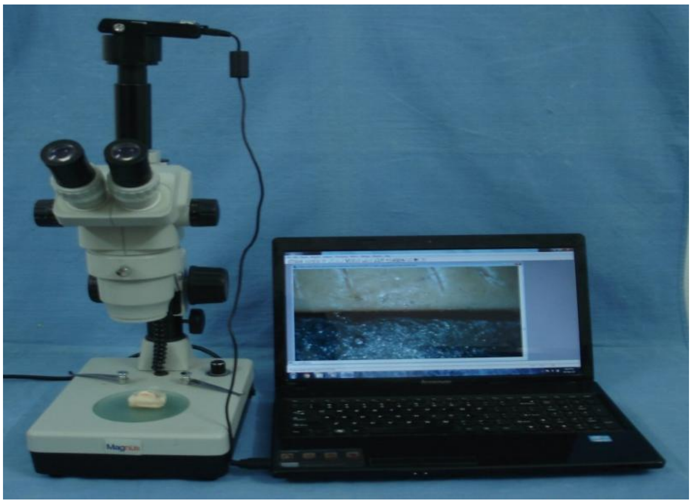


Fig No 25: optical stereomicroscope with compatible camera

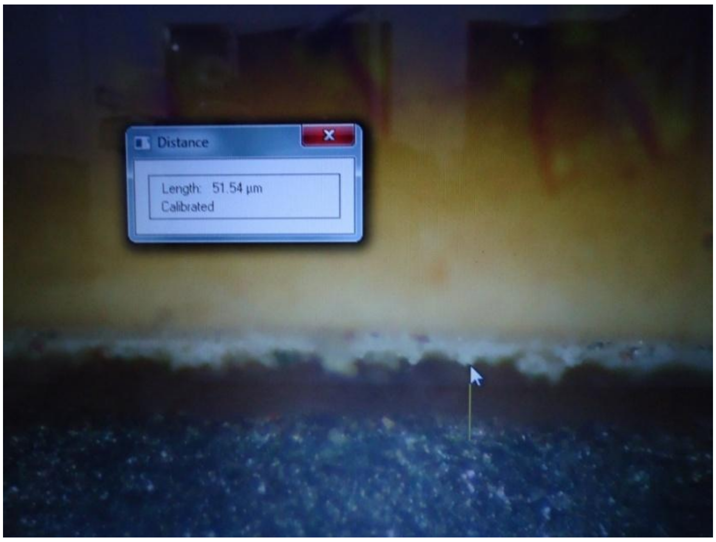


Fig No 26; Measuring images with software

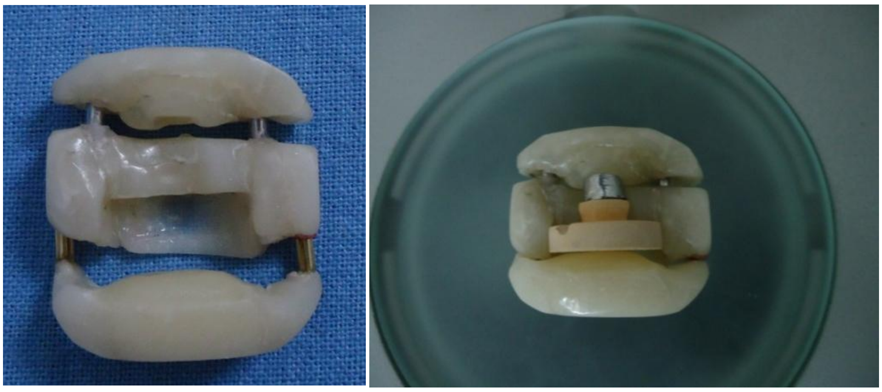


Fig No 27 : Custom made acrylic jig.

Fig No 28: Phosphate bonded investment Powder and liquid

Fig No 29 : Induction casting Machine

Fig No 30: Burn out furnace

Fig No 31: Plaster cutter

Fig No 32: Sand Blaster

Fig No 33: Lab Micromotor with carborundum disc

Fig No 34: Stage micrometer

Fig No 35: high speed lathe

Fig No 36:Finished and grouped specimens

Fig No: 37 custom made matallic template for fabrication of inlay wax and autopolymerising specimens

Fig no 38: Incubator

Fig no 39: hand held halogen light curing unit

Fig no 40: light curing chamber

RESULTS

The values of each measurement site for each specimen were tabulated.(Annexure-1 to 15)

<u>Comparison of two groups</u>

Student's "t" test for two independent groups is used to compare the significance of difference between two groups at 5% level of significance.

Note 1: If "p" value is more than 0.05, then we can conclude that there is no significant difference between the two groups considered with regard to mean.

Note 2: If "p" value is less than 0.05, then we can conclude that there is a significant difference between the two groups, considered with regard to mean.

<u>Comparison of more than two groups</u>

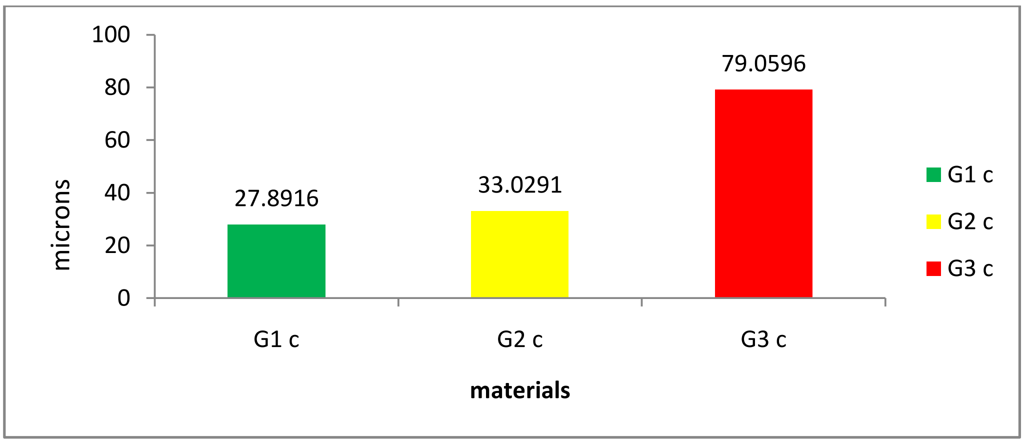
Analysis of Variance (ANOVA) test was used to compare the significance of difference between more than two groups at 5% level of significance.

Note 1: If "p" value is more than 0.05, then we can conclude that there is no significant difference between the two groups, considered with regard to mean.

Note 2: If "p" value is less than 0.05, then we can conclude that there is a significant difference between the two groups, considered with regard to mean.

In this study, both ANOVA test and student t test were used

Graph no 1: comparison between mean values of marginal discrepancy for G1c-inlay wax (27.89µm), G2c-Autopolymerized resin (33.02 µm), and G3c-Photopolymerized resin (79.05) specimens which were immediately invested and cast. (Annexure-1,2 and 3)



ANOVA

VAR00001					
	Sum of squares	df	Mean square	F	Sig.
Between groups	15877.884	2	7938.942	20.443	.000
Within groups	10485.068	27	388.336		
total	26362.952	29			

Table no 1: Comparison of the mean marginal discrepancy of different pattern materials which were immediately invested and cast using ANOVA to find presence of significant difference

Since the p value (.000) is less than 0.05, it can be concluded that there is a significant difference between the 3 groups considered.

Multiple Comparisons

VAR00001

LSD

(I) VAR00002	(J) VAR00002	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	-5.13750	8.81290	**.565**	-23.2201	12.9451
	3	-51.16800*	8.81290	**.000**	-69.2506	-33.0854
2	1	5.13750	8.81290	**.565**	-12.9451	23.2201
	3	-46.03050*	8.81290	**.000**	-64.1131	-27.9479
3	1	51.16800*	8.81290	**.000**	33.0854	69.2506
	2	46.03050*	8.81290	**.000**	27.9479	64.1131

*. The mean difference is significant at the 0.05 level.

Table no 2: Comparison of mean marginal discrepancy of each pattern material with other two materials which were immediately invested and cast to find level of significant difference.

LSD Statistical test shows that,

• p-value (.565) is more than 0.05 between groups 1 & 2, which shows that there is no significant difference between the two groups considered.

• p-value (.000) is less than 0.05 between groups 2 & 3, which shows that there is a significant difference between the two groups considered.

• p-value (.000) is less than 0.05 between groups 1 & 3, which shows that there is a significant difference between the two groups considered.

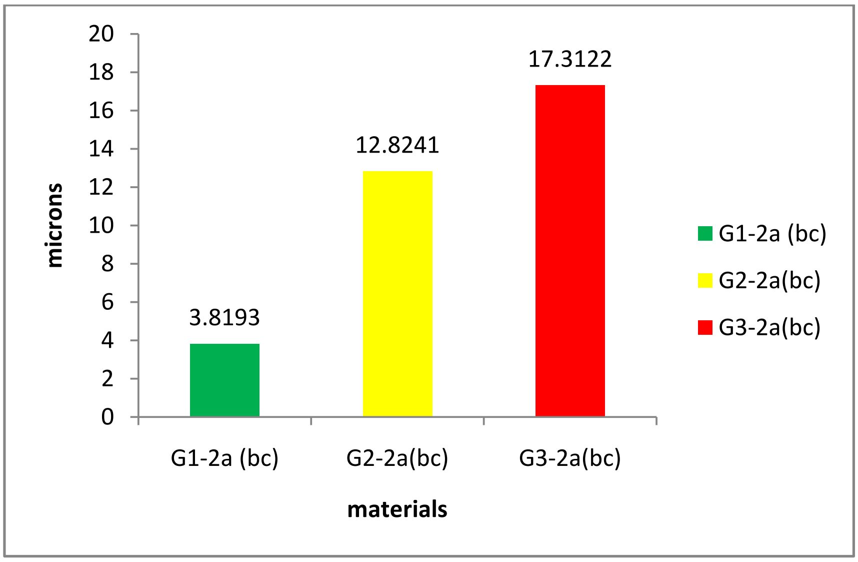
Results of the study for immediately invested and cast group shows that,

- Comparing inlay waxes, Autopolymerizing resin and photopolymerizing resin , inlay wax specimens (27.89µm) showed lesser marginal discrepancy than autopolymerized resin (33.02µm) and photopolymerized resin specimens.(79.05µm).

Through statistical analysis:

- By comparing inlay wax and Autopolymerized resin specimens there is no significant difference.
- By comparing Autopolymerized resin and photopolymerized resin specimens there is a significant difference.
- By comparing inlay wax and photopolymerized resin specimens there is a significant difference.

Graph no 2: comparison between mean values of marginal discrepancy for G1-2a(bc)-inlay wax(3.81µm),G2-2a(bc) (12.82µm)-Autopolymerized resin and G3-2a(bc)(17.31µm) – photopolymerized resin specimens stored at 0°c for 24 hours and measured before casting.(Annexure-4,5 and 6)



ANOVA

VAR00001

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	944.293	2	472.146	9.408	.001
Within Groups	1355.065	27	50.188		
Total	2299.357	29			

Table no 3: Comparison of mean marginal discrepancy of different pattern materials which were stored at 0^0c for 24 hours and measured before casting using ANOVA to find presence of significant difference

Since the p value (.001) is less than 0.05, it can be concluded that there is a significant difference between the 3 groups considered

MULTIPLE COMPARISONS

VAR00001 LSD

(I) VAR00002	(J) VAR00002	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	-9.00480*	3.16820	**.008**	-15.5054	-2.5042
	3	-13.49290*	3.16820	**.000**	-19.9935	-6.9923
2	1	9.00480*	3.16820	**.008**	2.5042	15.5054
	3	-4.48810	3.16820	**.168**	-10.9887	2.0125
3	1	13.49290*	3.16820	**.000**	6.9923	19.9935
	2	4.48810	3.16820	**.168**	-2.0125	10.9887

Table no 4: Comparison of mean marginal discrepancy of each pattern material with other two materials which were stored at 0^0c for 24 hours and measured before casting to find level of significant difference.

LSD Statistical test shows that,

- p-value (.008) is less than 0.05 between groups 1 & 2, which shows that there is a significant difference between the two groups considered.
- p-value (.168) is more than 0.05 between groups 2 & 3, which shows that there is no significant difference between the two groups considered.
- p-value (.000) is less than 0.05 between groups 1 & 3, which shows that there is a significant difference between the two groups considered.

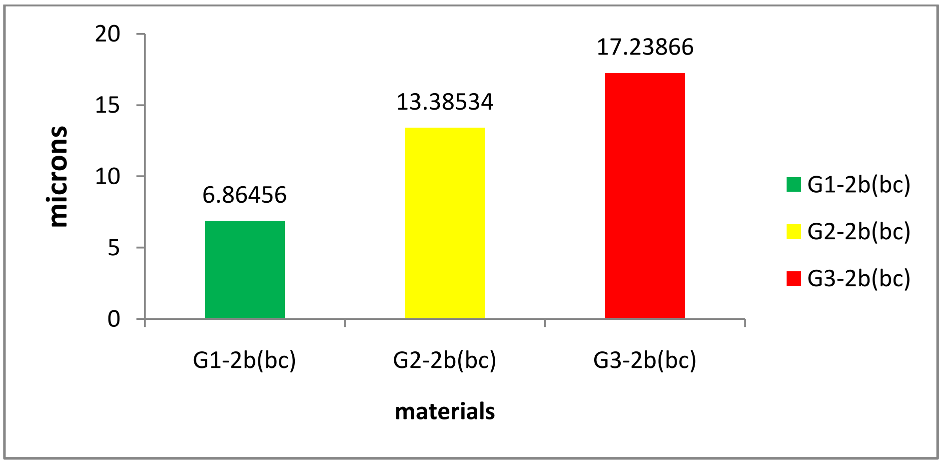
Results of the study for patterns which were stored at 0^0c for 24 hours and measured before casting:

- Comparing inlay wax, Autopolymerising resin and photopolymerizing resin, inlay wax specimens (3.81µm) showed lesser marginal discrepancy than autopolymerized resin (12.82µm) and photopolymerized resin specimens (17.31µm).

Through statistical analysis:

- By comparing inlay wax and Autopolymerized resin there is a significant difference.
- By comparing Autopolymerized resin and photopolymerized resin specimens there is no significant difference.
- By comparing inlay wax and photopolymerized resin specimens there is a significant difference.

Graph no:3 comparison between mean values of marginal discrepancy for G1-2b(bc) –inlay wax(6.86µm),G2-2b(bc)-Autopolymerized resin(13.38µm) and G3-2b(bc)- Photopolymerized resin (17.23µm) specimens which stored at ambient temperature for 24 hours measured before casting.(Annexure 7,8,and 9)



ANOVA

VAR00001

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	549.969	2	274.984	5.514	.010
Within Groups	1346.614	27	49.875		
Total	1896.583	29			

Table no 5: Comparison of mean marginal discrepancy of different pattern materials which were stored at ambient temperature for 24 hours and measured before casting using ANOVA to find presence of significant difference

Since the p value (.010) is less than 0.05, it can be concluded that there is a significant difference between the 3 groups considered.

Multiple Comparisons

VAR00001

LSD

(I) VAR00002	(J) VAR00002	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1	2	-6.52078*	3.15831	**.044**	-13.0011	-.0405
	3	-10.37410*	3.15831	**.003**	-16.8544	-3.8938
2	1	6.52078*	3.15831	**.044**	.0405	13.0011
	3	-3.85332	3.15831	**.233**	-10.3336	2.6270
3	1	10.37410*	3.15831	**.003**	3.8938	16.8544
	2	3.85332	3.15831	**.233**	-2.6270	10.3336

Table no 6: Comparison of mean marginal discrepancy of each pattern material with other two materials which were stored at ambient temperature for 24 hours and measured before casting to find level of significant difference

LSD Statistical test shows that,

- P-value (.044) is less than 0.05 between groups 1 &2,which shows that there is a significant difference between the two groups considered.
- p-value (.233) is more than 0.05 between groups 2 & 3, which shows that there is no significant difference between the two groups considered.
- p-value (.003) is less than 0.05 between groups 1 & 3, which shows that there is a significant difference between the two groups considered

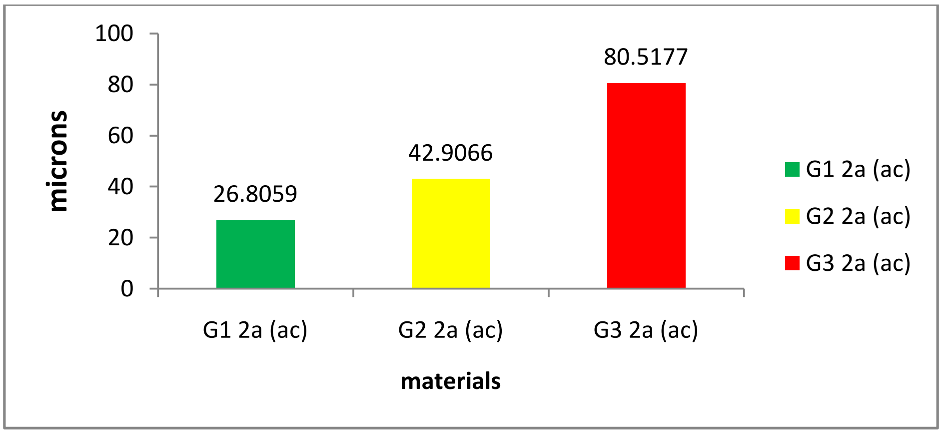
Results of the study for the patterns stored at ambient temperature, for 24 hours and measured before casting,

- By comparing inlay wax, Autopolymerising resin and photopolymerising resin, inlay wax specimens (6.86µm) showed lesser marginal discrepancy than autopolymerized resin (13.38µm) and photopolymerized resin specimens (17.23µm).

Through statistical Analysis,

- By comparing inlay wax and Autopolymerized resin specimens there is a significant difference
- By comparing Autopolymerized resin and photopolymerized resin specimens there is no significant difference
- By comparing inlay wax and photopolymerized resin specimens there is a significant difference

Graph no 4: comparison between mean values for marginal discrepancy of G1-2a(ac)-(inlay wax(26.8 µm),G2-2a(ac)-Autopolymerized resin (42.90µm)and G3-2a (ac)- Photopolymerized resin(80.51µm) specimens stored at 0^0c for 24 hours ,and measured after casting.(Annexure 10,11,and 12)



ANOVA

VAR00001

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	15195.949	2	7597.975	17.357	.000
Within Groups	11819.449	27	437.757		
Total	27015.398	29			

Table no 7: Comparison of mean marginal discrepancy of different pattern materials which were stored at 0^0c for 24 hours and measured after casting using ANOVA to find presence of significant difference

Since the p value (.000) is less than 0.05, it can be concluded that there is a significant difference between the 3 groups considered.

VAR00001

LSD

(I) VAR00002	(J) VAR00002	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	-16.10070	9.35689	**.097**	-35.2995	3.0981
	3	-53.71180*	9.35689	**.000**	-72.9106	-34.5130
2	1	16.10070	9.35689	**.097**	-3.0981	35.2995
	3	-37.61110*	9.35689	**.000**	-56.8099	-18.4123
3	1	53.71180*	9.35689	**.000**	34.5130	72.9106
	2	37.61110*	9.35689	**.000**	18.4123	56.8099

*. The mean difference is significant at the 0.05 level.

Table no 8:Comparison of mean marginal discrepancy of each pattern material with other two materials which were stored at 0^0c for 24 hours and measured after casting to find level of significant difference

LSD Statistical test shows that,

- p-value (.097) is more than 0.05 between groups 1 & 2, which shows that there is no significant difference between the two groups considered.

- p-value (.000) is less than 0.05 between groups 2 & 3, which shows that there is a significant difference between the two groups considered.

- p-value (.000) is less than 0.05 between groups 1 & 3, which shows that there is a significant difference between the two groups considered.

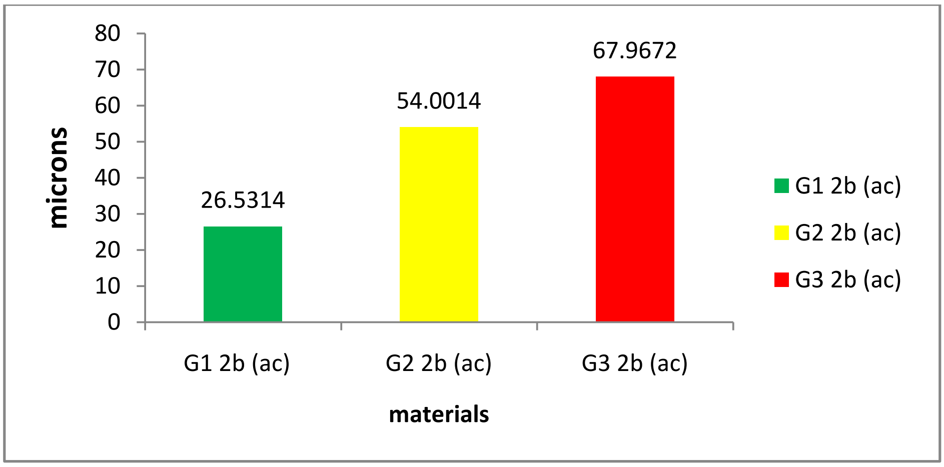
Results of the patterns when stored at 0^0c, for 24 hours and measured after casting shows that,

- By comparing inlay wax, Autopolymerising resin and photopolymerising resin, inlay wax specimens (26.80µm) showed lesser marginal discrepancy than autopolymerized resin (42.90µm) and photopolymerized resin specimens (80.51 µm).

Through statistical analysis:

- By comparing inlay wax and Autopolymerized resin specimens there is no significant difference
- By comparing Autopolymerized resin and photopolymerized resin specimens there is a significant difference
- By comparing inlay wax and photopolymerized resin specimens there is a significant difference.

Graph no 5: comparison of mean values of marginal discrepancy between G1-2b (ac) inlay wax(26.53µm),G2-2b (ac) Autopolymerized resin (54.0µm)and G3-2b (ac) Photopolymerized resin (67.96 µm) specimens stored at ambient temperature for 24 hours and measured after casting(Annexure 13,14,and 15)



.

ANOVA

VAR00001

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8888.567	2	4444.283	9.453	.001
Within Groups	12693.936	27	470.146		
Total	21582.502	29			

Table no 9: Comparison of mean marginal discrepancy of different pattern materials which were stored at ambient temperature for 24 hours and measured after casting using ANOVA to find presence of significant difference

Since the p value (.001) is less than 0.05, it can be concluded that there is a significant difference between the 3 groups considered

Multiple comparisons

LSD

(I) VAR00002	(J) VAR00002	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	-27.47000*	9.69686	**.009**	-47.3663	-7.5737
	3	-41.43580*	9.69686	**.000**	-61.3321	-21.5395
2	1	27.47000*	9.69686	**.009**	7.5737	47.3663
	3	-13.96580	9.69686	**.161**	-33.8621	5.9305
3	1	41.43580*	9.69686	**.000**	21.5395	61.3321
	2	13.96580	9.69686	**.161**	-5.9305	33.8621

***The mean difference is significant at the 0.05 level.**

Table no 10: Comparison of mean marginal discrepancy of each pattern material with other two materials which were stored at ambient temperature for 24 hours and measured after casting to find level of significant difference

LSD Statistical test shows that,

- p-value (.009) is less than 0.05 between groups 1 & 2, which shows that there is a significant difference between the two groups considered.

- p-value (.161) is more than 0.05 between groups 2 & 3, which shows that there is no significant difference between the two groups considered.

- p-value (.000) is less than 0.05 between groups 1 & 3, which shows that there is a significant difference between the two groups considered.

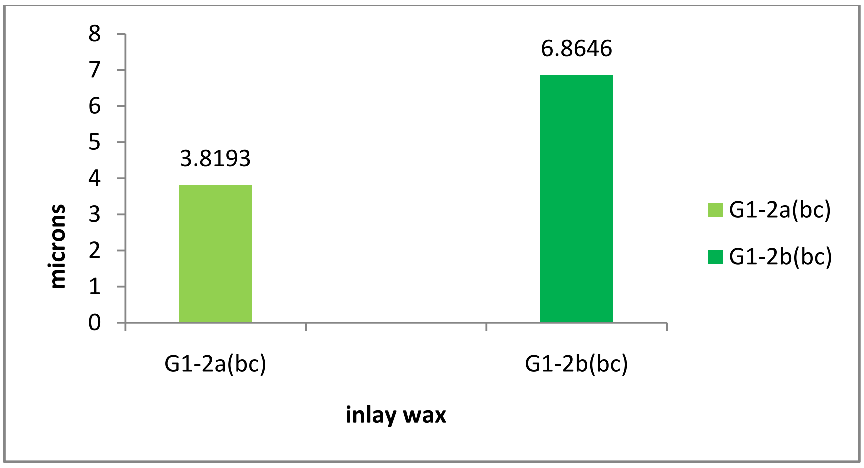
Results of the patterns stored at Ambient temperature, for 24 hours, and measured after casting shows that,

- Comparing inlay waxes, Autopolymerizing resin and photopolymerizing resin, inlay wax specimens (26.53µm) showed lesser marginal discrepancy than autopolymerized resin (54.0µm) and photopolymerized resin specimens (67.96µm).

Through statistical Analysis,

- By comparing inlay wax and Autopolymerized resin specimens there is a significant difference
- By comparing Autopolymerized resin and photopolymerized resin specimens there is no significant difference
- By comparing inlay wax and photopolymerized resin specimens there is a significant difference

Graph no 6: comparison between mean values for marginal discrepancy of G1-2a (bc) inlay wax (3.81µm) stored at 0^0c and G2-2b (bc) inlay wax (6.86µm) specimens stored at ambient temperature for 24 hours and measured before casting.



Student's "t" test

Group Statistics

	VAR00002	N	Mean	Std. Deviation	Std. Error Mean
VAR00001	1	10	3.8193	4.27136	1.35072
	2	10	6.8646	6.86613	2.17126

Table no 11: Comparison within mean marginal discrepancy of inlay wax specimens stored at 0^0c and at ambient temperature for 24 hours and measured before casting using student "t" test.

t	df	Sig. (2-tailed) **p-value**	Mean Difference	Std. Error Difference
1.191	18	**.249**	3.04526	2.55711

t = 1.191 & p= .249

***Table no 12: Descriptive statistics which shows p-value , mean difference, and std.error difference when comparing within inlay wax specimens stored at 0^0c and at ambient temperature for 24 hours and measured before casting*.**

Here the p-value (.249) is more than 0.05, hence it can be concluded that there is no significant difference between the means of the two groups considered.

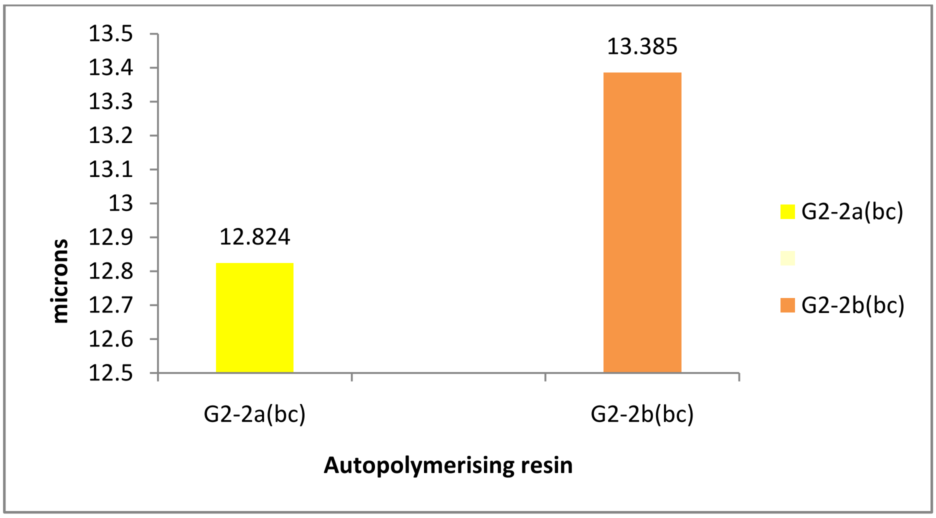
Results of the inlay wax specimens stored at 0^0c and at ambient temperature for 24 hours and measured before casting shows that,

- By comparing inlay wax specimens stored at 0^0c (3.81µm) and at ambient temperature (6.86µm), inlay wax specimens stored at 0^0c showed lesser marginal discrepancy.

Through statistical analysis,

- There is no statistical difference between inlay wax specimens stored at 0^0c and ambient temperature

Graph no 7: comparison between mean values for marginal discrepancy of G2-2a(bc) (12.82 µm)Autopolymerized resin specimens stored at 0^0c and G2-2b (bc)(13.38µm) Autopolymerized resin specimens stored at ambient temperature for 24 hours and measured before casting.



Group Statistics

	VAR00002	N	Mean	Std. Deviation	Std. Error Mean
VAR00001	1	10	12.8241	3.77056	1.19236
	2	10	13.3853	6.45475	2.04117

Table no13: Comparison within mean marginal discrepancy of Autopolymerizing resin specimens stored at 0^0c and at ambient temperature for 24 hours and measured before casting using student "t" test

t	df	Sig. (2-tailed) **p-value**	Mean Difference	Std. Error Difference
0.237	18	**.815**	0.56124	2.26391

t = 0.237 & p= .815

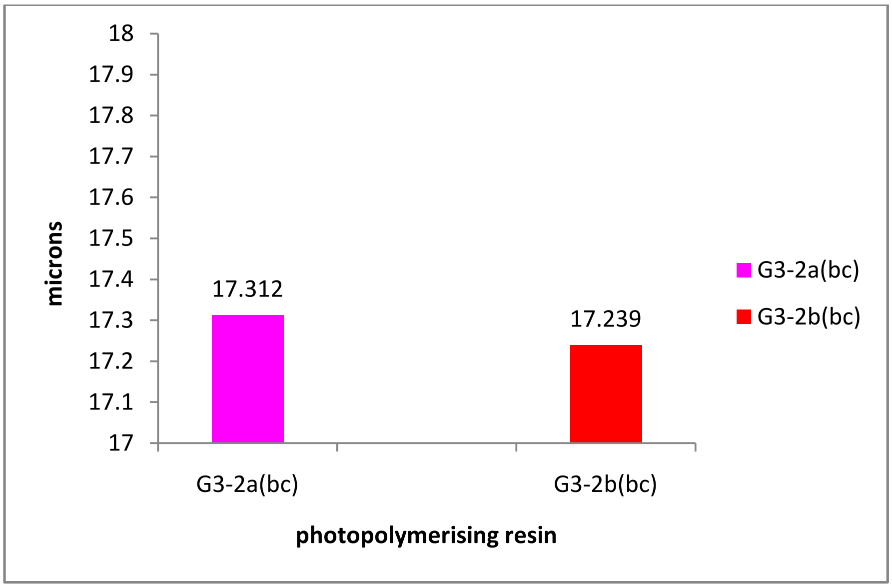
Table no 14: Descriptive statistics which shows p-value, mean difference, and std.error difference when comparing within Autopolymerizing resin stored at 0^0c and at ambient temperature for 24 hours and measured before casting

The p-value (.237) is more than 0.05, hence it can be concluded that there is no significant difference between the means of the two groups considered.

Results of the Autopolymerized resin specimens stored at 0^0c and at ambient temperature for 24 hours and measured before casting shows that,

- By comparing Autopolymerized resin specimens stored at 0^0c (12.82µm) and at ambient temperature (13.38µm), Autopolymerized resin specimens stored at 0^0c showed lesser marginal discrepancy.
- Through statistical Analysis,
- There is no statistical difference between Autopolymerized resin specimens stored at 0^0c and ambient temperature.

Graph no 8: Comparison between mean values for marginal discrepancy of G3-2a (bc) photopolymerized resin(17.31µm) and G3-2b (bc) photopolymerized resin (17.23µm)specimens stored at ambient temperature for 24 hours and measured before casting.



Group Statistics

	VAR00002	N	Mean	Std. Deviation	Std. Error Mean
VAR00001	1	10	17.3122	10.86743	3.43658
	2	10	17.2387	7.79849	2.46610

Table no 15: Comparison within mean marginal discrepancy of Photopolymerizing resin specimens stored at 0^0c and at ambient temperature for 24 hours and measured before casting using student "t" test

t	df	Sig. (2-tailed) **p-value**	Mean Difference	Std. Error Difference
0.017	18	**.986**	0.07354	4.22986

t = 0.017 & p= .986

Table no 16:Descriptive statistics which shows p-value, mean difference, and std.error difference when comparing within photopolymerizing resin stored at 0^0c and at ambient temperature for 24 hours and measured before casting

The p-value (.986) is more than 0.05, hence it can be concluded that there is no significant difference between the means of the two groups considered.

Results of photopolymerized resin specimens stored at 0^0c and at ambient temperature for 24 hours and measured before casting shows that,

- By comparing Photopolymerized resin specimens stored at 0^0c (17.31µm) and at ambient temperature (17.23µm), Photopolymerized resin specimens stored at ambient temperature showed lesser marginal discrepancy.

Through statistical Analysis,

- There is no statistical difference between photopolymerized resin specimens stored at 0^0c and ambient temperature.

DISCUSSION

Poor marginal discrepancy increases cement dissolution, as the surface of exposed cement is tripled when the width of discrepancy increases from 0.1 to 0.2mm. Poor marginal discrepancy can lead to plaque accumulation, gingival inflammation, bone loss, food accumulation, secondary caries, and failure of restorations. Others suggested sequelae from defective margins include occlusal disharmonies due to poor seating, leading to pulpitis or disturbances of the gnathostomatic system.[30]Open marginal configurations encourage micro leakage of bacteria and their by-products, due to dissolution of the luting agents. This can cause severe effects on the health of pulpal tissues. The relationship between margin adaptation and periodontal health has been confirmed in experimental animals and humans.[31]

Various marginal discrepancies in literature [30]:

Gulkerg et al ,stated that even good castings often exhibit discrepancies of 200 µm. Dedmon et al, discovered that prior to cementation only 9% of castings had sealing discrepancies greater than 39 µm. McLean and von Fraunhoferlg reported that inaccuracies of fit of 0.1 mm were normal. According to Christensen, the least acceptable visually accessible margin was 39 µm. Others have subsequently quoted this figure for assessing the acceptability of tooth to restoration marginal discrepancies and the associated marginal configurations. Palomo and Peden have emphasized that the mean opening for gingival margins in Christensen’s study was 74 µm, and that this was a more realistic dimension to evaluate gingival margin acceptability. Ostlund considered that subgingival openings less than 50 µm might be acceptable, while some other studies concluded that discrepancies exceeding 100 µm were unacceptable. Although some maintain that sharp explorers detect marginal gaps as small as 25 µm, McLean and von

Fraunhoferlg reported that discrepancies less than 80 um were difficult to detect under clinical conditions. Fusayama et al. investigated seating discrepancies and found cement lines with shoulder preparations of 44 to 48 µm. Wanserski et al.reported a maximum mean fabrication discrepancy for metal or porcelain shoulder margins of 37 µm, which agrees closely with the findings of others. Donovan and Prince demonstrated that gaps of only 6 to 34 µm are consistently attainable for porcelain ceramometal shoulder margins, and others agree that fabrication well within the 40 µm set by the American Dental Association is feasible. Scharer et al. reported post-cementation marginal gaps of 22 to 41.5 µm for porcelain foil crowns made on shoulder preparations, and reported discrepancies of 30 to 35 µm for aluminous porcelain jacket crowns.[30] For various reasons, the authors considered that successful restorations possessed marginal gaps less than 120 µm.

Wax products used in dentistry can be broadly classified as pattern, processing, and impression waxes. Pattern waxes include inlay wax, casting wax for RPD framework patterns, and baseplate wax[32]. Inlay waxes are of two types- type I and type II. Type I inlay waxes are used for direct wax pattern fabrication inside the oral cavity and Type II inlay waxes are used for indirect pattern fabrication in laboratory.

A regular or soft type of wax is typically used for indirect work at room temperature or in cool weather. A harder or medium type with a low flow property is indicated for use in warmer climates. The higher flow of softer waxes produce larger restoration than harder waxes because the softer waxes expand more as the investment heats up during setting and they offer less resistance to the expanding investment during setting[32].

CHARACTERISTIC PROPERTIES OF WAXES:

Generally, inlay wax may contain 60% paraffin (mineral), 25% carnuba (plant) 10% ceresin (mineral) and 5 % beeswax. (Animal). Like other materials, waxes expand when subjected to a rise in temperature and contract as the temperature is decreased. This fundamental property may be altered slightly when various waxes are blended in commercial products which make it difficult to predict or define each property, but the response to thermal changes cannot be reduced to negligible values.[8]

However, waxes have two major defects: A high coefficient of thermal expansion and a tendency to warp or distort upon standing.[9]

THERMAL EXPANSION OF INLAY WAXES [8]:

The linear thermal expansion properties of waxes may be explained on the basis of the strength of secondary valence forces and the transition points.

Certain waxes have weak secondary valence forces, which permits more movement of wax components which allow a greater amount of thermal expansion.eg mineral waxes.

On the other hand, plant waxes (car nauba) are blended with mineral waxes to reduce the thermal expansion because of strong secondary valence forces.

Transition point is the point where the internal structural parts become free to move. Consequently, after a wax has been heated through a transition point, it is free to expand. As more than one type of component are blended, commercial waxes undergo at least two transition points ; that is two rates of expansion which is usually between 22^{o} and 52^{0} c.

DISTORTION OF WAX [7,8]:

Distortion of a wax pattern results from occluded air in the pattern, physical deformation (during molding, carving or removal) release of stress "trapped" during previous cooling, excessive storage time and extreme temperature changes during storage.

Upon cooling it contracts and after attaining equilibrium, reaches a state of dimensional stability. To avoid distortion, the wax pattern is to be retained on the die for several hours to avoid distortion and ensure that equilibrium conditions are established.

Unquestionably some distortion of the wax pattern occurs as the investment hardens around it. The setting and hygroscopic expansions of the investment may produce a non uniform expansion of the walls of the pattern. This type of distortion occurs in part from the non uniform outward movement of the proximal walls. The gingival margins are forced apart by the mold expansion, whereas the solid occlusal bar of wax resists expansion during the early stages of setting.

The configuration of the pattern, the type of wax, and the thickness influence the distortion that occurs.

As the investment sets and setting expansion occurs, it eventually gains sufficient strength to produce a dimensional change in the wax pattern and mold cavity. If the pattern has a thin wall, the effective setting expansion is somewhat greater than that of a pattern with thicker walls because the investment can move the thinner wall more readily. Also, softer the wax, the greater is the effective setting expansion, because the softer wax is more readily moved by the expanding investment. If a wax softer than a type II inlay wax is used, the setting expansion may cause an excessive distortion of the pattern.

Inlay wax distortion and its clinical significance:

All the wax patterns, regardless of the method of manipulation, contain a varying degree of internal strain. This strain is induced [7] by

(1) The natural contraction of wax on cooling

(2) Change in the shape of the wax form by molding, compressing and so forth.

(3) Alteration of the pattern by pooling, patching, or carving.

Once the confining action of the preparation is removed, the strain starts to be relieved. Release of the strain is a definite function of the length of time during which the pattern is stored, and is influenced by the temperature at which the pattern is stored, and any changes of temperature to which the pattern is subjected after it is formed. The resulting distortion continues then until most of the strain has been released. Since higher temperatures raise the flow and lower the yield point of wax, the release of the internal strain is accelerated by any increase in storage temperature.[7]

The visco-elastic behavior of the waxes make them susceptible both to stress relief and relaxation, as residual stresses induced during manipulation of the wax disappear. Stress relief is the time –dependent reduction of residual stresses, manifested as a delayed elastic recovery, which produces a corresponding distortion. If the pattern is physically unconfined this is the normal way in which residual stresses disappear[33]. The rate at which stress relief occurs is highly temperature dependent and can be greatly reduced by cooling the wax pattern to temperature below ambient. Thus if wax patterns must be stored before investing, refrigeration is sometimes recommended. If the pattern is physically confined, for example a full crown pattern left on the die, this is the only way that residual stresses can disappear.[33]

Phillips et al, have done an exclusive study about storage time and storage temperature of inlay waxes. Even though the article, does not enumerate the numerical values of distortion, the authors have suggested several conclusions through their study which are as follows:

Effect of storage time [4]:

As the storage time was increased, the distortion became progressively worse. Although most of the distortion occurred during the first six hours, continued changes were noted upto 24 hours. The results of the study apparently suggested, that the higher the temperature at which the wax was manipulated, the fewer were the internal strains and the less was the resulting distortion upon storage. Since, the flow of wax decreases and the yield point increases as the temperature is lowered, it is possible that the patterns might be stored more safely at low temperatures and the strain would be more slowly released.

Effect of storage temperature[4]:

When the patterns were made from inlay wax, which was molded at a temperature of 120^{0}F and stored at a temperature of 52 ^{0}F and 36^{0} F, the distortion was less.

Even though several articles and publications have described about the effects of temperature and time on inlay waxes and have concluded that there was an increase in distortion as temperature and time of storage were increased, there have been very few studies that have shown the effect of storage temperature and time on resins and waxes, before and after casting. So the aim of the current study was to evaluate and compare the marginal discrepancies in resins and waxes before and after casting, which occurred after storing them at different time and temperature.

CLINICAL EVALUATION OF FIT OF CASTINGS:

The tolerance limits for the fit and marginal adaptation of a cast restoration are not known. Certainly a high degree of accuracy in marginal adaptation of 25 µm or less cannot be guaranteed for all cast restorations. It stands to reason that the more accurate the fit of the casting, the less the likelihood of marginal leakage, plaque accumulation on the cement, and thereby formation of secondary caries.

Hollenback stated that well-fitting castings, unless they were relieved an optimum 25 µm, might fail to completely seat by as much as 100 µm. In one study, a group of dentists evaluating cast restorations with an explorer, rejected discrepancies greater than 40 µm on accessible margins but accepted subgingival margins with 120 µm discrepancies[34]. Another study compared radiographic and clinical findings. Radiographically, margin discrepancies less than 80 µm were difficult to detect. With the use of an explorer with an average 80 µm radius in a clinical examination, a 200 µm discrepancy was barely discernible[34]. The result of the study revealed that castings considered clinically and radiographically acceptable had marginal discrepancies ranging from 10 to 160 µm.[34]

Increasing the film thickness by 1 µm produces an 11.5 µm occlusal discrepancy, and produces the same discrepancy at the margin when a 90-degree shoulder is used.[34]

Introduction about Autopolymerizing pattern resin

Auto-polymerized acrylic resins (introduced in 1950) have been used for castings requiring greater dimensional stability.[12,35] Generally, two methods for Autopolymerized resins are used, namely, the conventional mixing technique (standard liquid :powder ratio) and the brush on technique. Shirato reported the L/P ratio of both techniques for autopolymerized resins (brush –on technique: 0.31- 0.38 L/P, mixing technique: 0.5 L/P). The brush –on technique was developed by Nealon. A bead of slurry resin attached to the end of the brush is placed in an incremental manner on the die to reduce polymerisation shrinkage. The procedure is repeated at 10 -15 second intervals. The brush –on technique indicated significantly more dimensional accuracy than the conventional mixing technique as it compensated for the shrinkage and had a lesser powder to liquid ratio.[35]

Since the auto polymerizing resin with a brush on technique had better results it was decided to use the GC Autopolymerising resin in this study.

Introduction about primopattern[36]

In 2009,new pattern resins were introduced (primopattern; primotec),which have been described as a "light cured universal modelling resin, ready to use one-component-material, available as modeling gel and modeling paste". The manufacturer of primopattern claims that the photopolymerizing materials have a working time of greater than 20 minutes; thus the effect of premature polymerization from ambient light can likely be considered minimal.[36]

The study conducted by Gibbs[36] et al, concluded that volumetric shrinkage values of duralay,GC pattern resin and primopattern LC gel were in the range of (5.07 to 5.72 %) and primopattern LC pattern paste had the highest shrinkage (7.43%).The photopolymerising pattern resin in gel form had the same shrinkage value as the Autopolymerizing pattern resins, but the photopolymerising pattern resin in paste form had significantly higher shrinkage value. According to the material safety data sheets, primopattern LC gel is composed of acrylic resin, fillers and initiators similar to GC pattern resin. As compared to primopattern paste form, primopattern gel form has least shrinkage. Hence, in this study gel form of primopattern was used.

DISADVANTAGES OF LIGHT ACTIVATED RESINS:

Marginal stress build up during curing is much higher than in self cured resins. This is due to faster cross –linking and thus reduced time for chains to slide among themselves and relaxation of interfacial stress build up due to curing shrinkage.[7]

CURING SHRINKAGE AND SHRINKAGE STRESS OF LIGHT CURE RESINS [7]:

Curing shrinkage occurs as a result of conversion of monomer into polymer and also due to the reduction in the free space occupied by them.(approximately 20% less than that among unreacted monomers).In turn, this polymerisation shrinkage produces unrelieved stresses in the resin after it reaches the' gelation' point and begins to harden[7]. The polymerisation shrinkage and resultant stress can be affected by the following:

1. Total volume of the composite material

2. Type of composite

3. Polymerisation speed

4. Ratio of bonded/non bonded surfaces or configuration of the tooth preparation.

The polymerisation shrinkage can be reduced by[7]

- Usage of higher molecular weight component eg: Bis-GMA has five times more molecular weight than MMA.
- The Addition of inorganic fillers which do not enter into polymerisation process, although they do not bond to the polymer. Thus, because a percentage of the volume does not enter into the reaction, the amount of monomer necessary and the curing shrinkage are reduced.

Goodacre[14] et al stated that a clinically prepared crown should exhibit certain features for its long term success.

According to the article[14], teeth should be prepared so that they exhibit the following characteristics:

- 10 to 20 degrees of total occlusal convergence,
- A minimal occlusocervical dimension of 4 mm for molars and 3 mm for other teeth,
- An occlusocervical –to- faciolingual dimension ratio of 0.4 or greater and
- Finish line selection should be based on the type of crown/retainer, esthetic requirements, ease of formation and personal experiences. Line angles are to be rounded and a reasonable degree of surface smoothness is desired.

In this study, the total occlusal convergence angle of the master die was 16 degrees. The occlusocervical dimension was kept as 4mm, occlusocervical-to faciolingual dimension ratio of 0.5 (4/7). Schillinburg[1] has recommended a shoulder finish line for metal ceramic restoration. In this study, metal copings were fabricated for full ceramic coverage restorations with a shoulder finish line that would be easy for manipulation and inspection.

Measurement of each coping was done randomly at 50 points[37]. A study[37] concluded that measuring at 25 points either systematically or randomly can give reliable information about marginal discrepancy.

The thickness of the specimen fabricated in this study was 0.3 mm. clinically; a recommended metal coping thickness can be as thin as o.2mm if base metal is used. Even at 0.2mm base metal alloys have higher yield strength and elevated melting temperature compared to a noble metal coping.[1]

All the specimens fabricated in the study should be even in thickness and it should be achieved by least manipulation. Since waxes were more susceptible to distortion because of manipulation, as noted in earlier studies. A master coping was constructed by direct metal laser sintering method which is more accurate than conventional fabrication. Over the master (DMLS) coping, a custom made metallic template was constructed which provided a uniform space of 0.3 mm, overall crown dimension including the marginal area. The metallic template was used to fabricate the specimens with least manipulation.

The material which was chosen for making an impression of the master die was poly vinyl siloxane impression material. PVS (polyvinyl siloxane)[16] had the best fine detail reproduction and elastic recovery of all available materials, and thus was the impression material of choice for fixed prosthodontics. A Less hydrophobic PVS material Aquasil, (caulk/Denstply,Milford) one of the materials recommended[16], was used in this study.

Craig et al [38] suggested the use of vinyl gloves instead of rubber latex as it prevented poisoning of the chloroplatinic acid catalyst in the addition silicones. To minimize the effect, vinyl gloves was used while making impression.

Among various techniques[15] for making an impression the two step putty wash impression technique produced accurate impressions which were followed in this study. An acrylic coping with 1mm thickness covering all over the coronal portion including the marginal areas was prepared to make a controlled putty-wash impression technique[18]. A maximum of two dies can be poured by using each impression which produced clinically insignificant dies [17] .Therefore, in this study only two dies were poured from each impression. According to the American dental association specification no 19, manufactures setting time can be doubled to compensate for polymerisation at room temperature rather at mouth temperature [6](37^0 c).The impressions were separated and then aged by 15 minutes [19] bench set at room temperature before being poured in stone die. The class IV die stone was mixed in the ratio of 100 grams powder with 23 ml of distilled water for 30 seconds according to the manufacturer instructions. The impressions were poured with the help of a vibrator to reduce voids [21]. The die was separated from the impression after 1 hour. [20] One layer of die harderner was applied over the stone dies to increase the surface hardness and scratch resistance[22].

Four layers of die spacer were applied on the die covering all areas but o.5mm short of margin of the dies[24]. The use of a die spacer was founded primarily on the concept that a uniform and specific amount of space between the tooth and casting allows the cement to escape and decreases hydrostatic pressure[34] .The amount of relief suggested is in the range of 20 to 40 µm. Fusayama, reported that film thickness of most cements was approximately 20 µm and stated that a thickness greater than 30 µm would contribute to solubility and failure of the restoration. Jorgensen and Esbensen, et al ,found that cement strength diminished approximately one third as the thickness of cement increased from 20 to 140 µm[34]. The amount of relief suggested is in the range of 20 to 40 µm. ADA specification No. 8 for zinc phosphate cement allows for 25 µm cement film thickness, the die spacer thickness used by most investigators.[34]

In this study the red colour (yeti) spacer was used to create space for ideal cement film thickness.

As per the manufacturer instructions each layer (red colour) produces 7µm thickness approximately. In the current study, four layers were applied after drying the previous layer, which can give a total spacer thickness of about 20 to 30µm.[23]

A Single layer of lubricant was applied and the excess was removed using an air syringe.

In this study, a wax pot was used to melt inlay wax uniformly. The temperature was set at 120^0F and maintained for 15 minutes before preparing the specimens. The temperature of 120^0F was arbitrarily selected since it is the approximate temperature at which most commercially available waxes can be readily molded.[4]

Autopolymerising resin (GC corp) was most commonly used to make patterns in recent times. Hence, it was used in this study. Incremental Technique was used to fabricate the copings, as suggested by various other studies[13, 35] compared to the bulk technique.

During examination under microscope, the specimens should be laid flat to observe the marginal discrepancy. So, expanded copings may show a different discrepancy (mostly high) than the actual discrepancy. Some authors have explained about applying finger pressure to seat the copings while others have used an orientation jig during examination. Force is a vector quantity that should be explained as amount of force applied and direction of force applied. A device had to be constructed to control these two factors. If finger pressure is used directly on the copings, the direction may vary each time that could cause seating errors due to tipping of copings.

To control the direction of force and also to apply the force evenly, a jig was fabricated. By using that, both the flat surfaces of the jig and copings could contact evenly, thereby preventing the tipping of copings.

The jig was opened and closed with the help of die pins, as seen in the figure (27). The amount of force used may vary but is made even, by using the jig.

A stage micrometer was set to make measurements by using a stereomicroscope. The stage micrometer is a slide which has calibration as seen in normal scales but the calibration will be in microns. A picture has to be taken at the same magnification which is to be used for measuring the marginal gap. Then the picture is stored in the computer with compatible software which is used as default calibration file. The compatible software used in this study is CMIEAS. Each specimen was photographed 5 times, at random sites. Each digital image was then measured at ten sites. Thereby, 50 measurements were made in total, for each coping.

In this study, vertical marginal gap was measured using direct view technique. According to Holmes[39], "the vertical marginal misfit measured parallel to the path of draw of the casting is called vertical marginal discrepancy". For measuring the gap between the crown and the die at the margins, but not internally, direct view technique uses a microscope at different magnifications. It reduces the accumulation of errors that may result from multiple procedures and ultimately has an impact on accuracy of the results[40]. Among direct view techniques, [31]a study compared the efficiency of explorer, elastomeric disclosing media and stereomicroscope. Among them, the stereomicroscope yielded the best results.

Results of a study[31] reported that at 30 µm an explorer revealed 39% sensitivity and 91 % specificity and elastomeric disclosing media revealed 10.06% sensitivity and 82 % specificity. A

Cross sectional technique is not suitable for long term analysis, because the same specimens cannot be used for comparing the results at different manufacturing stages and also limited measuring points in the sectional plane may not represent the complete fit of the crown.

The results of the study showed that inlay wax (27.89µm) has lesser marginal discrepancy than Autopolymerizing resin (33.02µm) and photopolymerizing resin (79.05µm), when invested and cast immediately.

A probable explanation that can be given for the better marginal accuracy of the castings using the inlay wax (400ppm $/^{0}$k) is its higher coefficient of thermal expansion compared to the resin (81ppm $/^{0}$k).This will provide a bigger mold space due to expansion of wax during the setting of the investment.[5] Hence, slightly bigger castings are obtained with better adaptation. In case of photopolymerising resin, the probable cause of poor marginal adaptation could be due to the high technique sensitivity. photopolymerising resins, rely on light with sufficient intensity to initiate polymerisation. But, the intensity of light will be greater at the surface of specimen, than at deeper levels, as it is attenuated by absorption and scatter, which limit, the depth of cure[5].

Patterns made from resins showed lesser expansion and caused tight binding of castings with the die. The reason might be as stated in the article "the resin patterns can distort because of polymerisation shrinkage, and they can suppress setting expansion of the investments more than wax patterns because of the higher rigidity of the cured resin[41]."

The copings made from pattern waxes could expand more than the resins during setting expansion and thereby could be a reason for complete seating of copings.

If resins undergo less expansion they might bind in the upper 1/3 rd of the die and may cause incomplete seating in the marginal region, sequentially causing more marginal discrepancy. This might be a reason for observation of more marginal discrepancy in resins after casting which was not significant before casting.

After 24 hours of storage, at 0 ^{0}c, before casting, the results of this study concluded that inlay wax (3.81µm) showed lesser marginal discrepancy than autopolymerising resin (12.82µm) and photopolymerising resin (17.31µm).

After 24 hours of storage, at ambient temperature, before casting, the results of this study concluded that inlay wax (6.86µm), showed lesser marginal discrepancy than the two resins - autopolymerising resin (13.38µm) and photopolymerising resin (17.23µm), which was statistically significant.

The results for waxes were better due to the reduction in release of residual stresses when kept at 0^{0}c and a reduction in internal strain due to controlled physical restrainment as copings were retained on dies. The reduction of distortion might be due to the press and pour method, thickness of pattern and less stress during fabrication because of high temperature molding. Resins undergo polymerisation shrinkage which is inevitable and they are less susceptible to the effect of temperature and storage time after they completely set. The mean values were almost same for both the Autopolymerizing and light cure resins at two different temperatures and the slight difference in the mean values might be due to the technical errors and different initiators present in the resins.

Iglesias[13] in his study concluded that, marginal gap for full crown patterns ranged from 10 to 23 µm. The marginal gap produced by incremental technique was equal or smaller than the bulk technique. In his study, incrementally added autopolymerising resins showed marginal discrepancy of 11± 3 (9 to 14µm) for Palavit and 19 ±7 (12 to 26µm) for Duralay and for light cure resin 13 ±5 (9 to 18µm) for Traid VLC.

The Marginal discrepancy of Autopolymerizing resin stored at ambient temperature for 24 hours before casting in this study was (13.38µm) and light polymerized resins was (17.23 µm).But in case of wax, the marginal discrepancy in this study was less when compared to the previously mentioned study. This might be due to procedural errors (same specimens were checked twice in between the procedure using finger pressure) and the difference in fabrication steps in the earlier study. The previous study has not explained about the dimensions of the die, usage of a matrix and thickness of the patterns.

The results of this study correlated with the study done by rajagopal [9] et al, and the values differed within a range of ± 6 µm for both resins. When comparing the values for inlay wax, both the studies showed different distortion levels. In the previous study, there was an increased distortion which might have resulted from the difference in room temperature, thickness of specimens, type of sleeve used and usage of the same metal die for checking all specimens.

In a study by komajian and holmes [6] , it was found that Autopolymerizing pattern resin showed significantly lesser marginal discrepancy than wax and VLC traid resin. The results of the current study correlates with their study in that Autopolymerizing resin showed lesser marginal discrepancy than light activated resin. There was a slight difference in the mean values between the two studies. In the earlier study, the Standard deviation and mean values were reduced which might be due to the usage of an orientation jig for examination before the casting stage. The mean value for inlay wax in the previous study was increased ,which might be due to the high ambient temperature in Saudi arabia (40°c) which is closer to its softening temperature.

Results of the study done by sushma[12] et al showed a mean marginal discrepancy of 165.62 microns for inlay wax, 177.7 microns for light cure resins and 184.43 microns for Autopolymerizing resins. Even though they had used SEM analysis, they had measured only two points for each side for reliable results, which is questionable. The other reasons for a higher value may be due to the difference in the amount of material resulting from a opened sleeve and cooling of wax without pressure. For light cure resins, the higher value might be due to limited polymerisation, because the distance between the sleeve and die was 1.5mm and the height of the die was 5mm .This would have made the light to be positioned 5 mm away from the die, leading to partial polymerization of the material furthest away from the source Another reason for higher values might be due to the non application of finger pressure during the examination which was not explained in that study.

Another study[5] had measured the marginal discrepancy at two points after sectioning the copings. The mean marginal discrepancy of these two points for inlay wax specimens were 72.36µm and 89µm and Autopolymerizing resin specimens were 59.27µm and 88.31µm which were much higher than those attained in the current study. The reason might be due to the stress created in sectioning the copings.

SUMMARY AND CONCLUSION

All the pattern materials used in the study showed clinically insignificant results. Inlay wax specimens showed better marginal accuracy than Autopolymerized and photopolymerized resin specimens stored for 24 hours, and measured before casting. Factors like use of press and mold technique, uniform heating and molding temperature of wax patterns made with minimal thickness were considered to arrive at the above conclusion. When compared within pattern materials, kept at 0^0c or ambient temperature, they showed insignificant difference. Both inlay wax and Autopolymerized resin specimens immediately cast, and stored for 24 hours at 0 ^{0}c showed better marginal accuracy than photopolymerized resin specimens. At the end of this study, the first null hypothesis was rejected and second null hypothesis was accepted.

Within the limitation of the study, the following conclusions were drawn from this in vitro study

- Inlay wax specimens and Autopolymerized resin specimens, after immediately casting showed better marginal accuracy than photopolymerized resin specimens.
- Inlay wax specimens stored for 24 hours, at 0^0c, and measured before casting showed better marginal accuracy than Autopolymerized resin and photopolymerized resin specimens.
- Inlay wax specimens stored for 24 hours, at ambient temperature, and measured before casting showed better marginal accuracy than Autopolymerized resin and photopolymerized resin specimens.
- Inlay wax specimens and autopolymerized resin specimens stored for 24 hours, at 0^0 c, and measured after casting showed better accuracy than photopolymerized resin specimens.

- Inlay wax specimens stored for 24 hours, at ambient temperature, and measured after casting showed better marginal accuracy than Autopolymerized and photopolymerized resin specimens.
- Comparing within pattern materials, when stored at 0^0c or ambient temperature none of the materials showed statistically significant difference.

BIBLIOGRAPHY

1. Shillingburg H.T, Hobo S, Whitsett LD, Jacobi R, Brackett SE, Fundamentals of fixed prosthodontics.3rd ed.chicago:Quintessence Pub.Co.; 1997.
2. Teteruck WR, Mumford G. The fit of certain dental casting alloys using different investing materials and techniques. J Prosthet Dent. 1966 Sep-Oct;16(5):910-27.
3. Kotsiomiti E, Kaloyannides A. Crown pattern waxes: a study of their behavior on heating and cooling. J Prosthet Dent. 1994 May;71(5):511-6.
4. PHILLIPS RW, BIGGS DH. Distortion of wax patterns as influenced by storage time, storage temperature, and temperature of wax manipulation. J Am Dent Assoc. 1950 Jul;41(1):28-37.
5. Shaikh SA, A comparative evaluation of marginal and internal adaptation of complete cast coping fabricated using different pattern materials –an in vitro study .Annals of Dental Specialty.2014 Oct-Dec; 2(4): 118-123
6. Abdullah M.A and Al Jabab,A.S .Storage time effect on marginal fit of full crown patterns made of wax,autopolymerized and light polymerized resin materials.Saudi Dental Journal 2005 sep-Dec 17(3);146-153.
7. PhillipsRW. Skinner's science of Dental Material, 10thed.Philadelphia:WB Saunders,1996:461
8. Craig RG: Restorative Dental Materials.St Louis,MO,Mosby-Year Book,1993,pg 362-381
9. Rajagopal P, Chitre V, Aras MA. A comparison of the accuracy of patterns processed from an inlay casting wax, an auto-polymerized resin and a light-cured resin pattern material. Indian J Dent Res. 2012 Mar-Apr;23(2):152-6.

10. Truffier-Boutry D, Demoustier-Champagne S, Devaux J, Biebuyck JJ, Mestdagh M,Larbanois P, Leloup G. A physico-chemical explanation of the post-polymerizationshrinkage in dental resins. Dent Mater. 2006 May;22(5):405-12
11. http://www.gcindiadental.com/wpcontent/uploads/ifu/GC_Pattern_Resin_IFU.pdf
12. Sushma R, Farias A, Soni R. Vertical marginal discrepancies of metal castings obtained using different pattern materials: A scanning electron microscope study.J Int Clin Dent Res Organ 2014; 6: 98-102.
13. Iglesias A, Powers JM, Pierpont HP. Accuracy of wax, autopolymerized, and light-polymerized resin pattern materials. J Prosthodont. 1996 Sep;5(3):201-5.
14. Goodacre CJ, Campagni WV, Aquilino SA. Tooth preparations for complete crowns:an art form based on scientific principles. J Prosthet Dent. 2001.Apr;85(4):363-76.
15. Chugh A, Arora A, Singh VP. Accuracy of different putty-wash impression techniques with various spacer thickness. Int J Clin Pediatr Dent. 2012 Jan;5(1):33-8.
16. Hamalian TA, Nasr E, Chidiac JJ. Impression materials in fixed prosthodontics:influence of choice on clinical procedure. J Prosthodont. 2011 Feb;20(2):153-60.
17. Kumar D, Madihalli AU, Reddy KR, Rastogi N, Pradeep NT. Elastomeric impression materials: a comparison of accuracy of multiple pours. J Contemp Dent Pract. 2011
18. Marshak B, Assif D, Pilo R. A controlled putty-wash impression technique. J Prosthet Dent. 1990 Dec;64(6):635-6
19. http://www.dentsply.de/bausteine.net/file/showfile.aspx?downdaid=7334&sp=D&domid=1042&fd=2
20. http://www.kalabhai.com/products/plasters/ultrarock.htm

21. Abdullah MA. Effect of frequency and amplitude of vibration on void formation in dies poured from polyvinyl siloxane impressions. J Prosthet Dent. 1998 Oct;80(4):490-4.
22. Ghahremannezhad HH, Mohamed SE, Stewart GP, Weinberg R. Effects of cyanoacrylates on die stone. J Prosthet Dent. 1983 May;49(5):639-46.
23. http://medicinoserdve.lt/mderdve/wp-content/uploads/2014/03/Katalog-yeti-2013-engl.pdf
24. Olivera AB, Saito T. The effect of die spacer on retention and fitting of complete cast crowns. J Prosthodont. 2006 Jul-Aug;15(4):243-9.
25. http://www.keystoneindustries.com/sites/all/files/Yeti%20Lube%20isolating%20liq550.pdf
26. Metavest,phosphate bonded investment, user manual.
27. https://us.shop.ivoclarvivadent.com/zoolu-website/media/document/1496/4All
28. http://www.gcamerica.com/lab/products/PATTERN_RESIN_LS/pattern_resin_tech_guide.pdf
29. http://www.primogroup.de/newsletter/primopattern/e/primopattern_Arbeitsanleitung.pdf
30. Hunter AJ, Hunter AR. Gingival margins for crowns: a review and discussion. Part II:Discrepancies and configurations. J Prosthet Dent. 1990 Dec;64(6):636-42.
31. Rastogi A, Kamble V. Comparative analysis of the clinical techniques used in evaluation of marginal accuracy of cast restoration using stereomicroscopy as gold standard. J Adv Prosthodont. 2011 Jun;3(2):69-75.
32. Diwan R, Talic Y, Omar N, Sadig W. Pattern waxes and inaccuracies in fixed and removable partial denture castings. J Prosthet Dent. 1997 May;77(5):553-5.

33. Morey EF. Dimensional accuracy of small gold alloy castings. Part 1. A brief history and the behaviour of inlay waxes. Aust Dent J. 1991 Aug;36(4):302-9.
34. Schwartz IS. A review of methods and techniques to improve the fit of cast restorations. J Prosthet Dent. 1986 Sep;56(3):279-83.
35. Hanatani.S.Dimensional accuracy of accuracy of autopolymerized resin applied using the brush –on technique. Int chin J Dent 2009;9: 9-13
36. Gibbs SB, Versluis A, Tantbirojn D, Ahuja S. Comparison of polymerization shrinkage of pattern resins. J Prosthet Dent. 2014 Aug;112(2):293-8
37. Groten M, Axmann D, Pröbster L, Weber H. Determination of the minimum number of marginal gap measurements required for practical in-vitro testing. J Prosthet Dent. 2000 Jan;83(1):40-9.
38. Craig RG. Review of dental impression materials. Adv Dent Res. 1988 Aug;2(1):51-64.
39. Holmes JR, Bayne SC, Holland GA, Sulik WD. Considerations in measurement of marginal fit. J Prosthet Dent. 1989 Oct;62(4):405-8
40. Nawafleh NA, Mack F, Evans J, Mackay J, Hatamleh MM. Accuracy and reliability of methods to measure marginal adaptation of crowns and FDPs: a literature review. J Prosthodont. 2013 Jul;22(5):419-28.
41. Takahashi J, Kitahara K, Teraoka F, Kubo F. Resin pattern material with low polymerization shrinkage. Int J Prosthodont. 1999 Jul-Aug;12(4):325-9.
42. Katta sridhar chowdary. Evaluation of marginal fit of castings made with Nickel-chromium and cobalt chromium alloys using varying coats of die spacers.A laboratory study. ijds 2011;5(3):4-9

43. Takahashi J, Kitahara K, Teraoka F, Kubo F. Resin pattern material with low polymerization shrinkage. Int J Prosthodont. 1999 Jul-Aug;12(4):325-9.

44. Mojon P, Oberholzer JP, Meyer JM, Belser UC. Polymerization shrinkage of index and pattern acrylic resins. J Prosthet Dent. 1990 Dec;64(6):684-8.

45. J. Ghanbarzadeh. The Effect of Storage Conditions on Dimensional Changes of Acrylic Post-Core Patterns. Journal of Dentistry 2007; 4 (1): 27-31.

46. Y. Suzuki.Handling efficiency of autopolymerized resin applied using the brush-on technique., Int chin J Dent 2009;9:33-38.

47. Jörgensen KD, Ono T. Distortion of wax crowns. Scand J Dent Res. 1984 Jun;92(3):253-6.

48. Whitworth JM, Makhani SH, McCabe JF. Cure behaviour of visible light-activated pattern materials. Int Endod J. 1999 May;32(3):191-6.

49. SMYD ES. Factors which influence casting accuracy; a universal casting technic. J Am Dent Assoc. 1948 Feb;36(2):160-72

50. Danesh G, Davids H, Reinhardt KJ, Ott K, Schäfer E. Polymerisation characteristics of resin composites polymerised with different curing units. J Dent. 2004Aug;32(6):47988.

51. Plekavich EJ, Joncas JM. The effect of impression-die systems on crown margins. J Prosthet Dent. 1983 Jun;49(6):772-6.

52. Sabouhi M, Nosouhian S, Dakhilalian M, Davoudi A, Mehrad R. The effect of time and storage environment on dimensional changes of acrylic resin post patterns.Open Dent J. 2015 Jan 30;9:87-90.

53. Ito M, Yamagishi T, Oshida Y, Munoz CA. Effect of selected physical properties of waxes on investments and casting shrinkage. J Prosthet Dent. 1996 Feb;75(2):211-6.

54. Ehrenberg D, Weiner GI, Weiner S. Long-term effects of storage and thermal cycling on the marginal adaptation of provisional resin crowns: a pilot study. J Prosthet Dent. 2006 Mar;95(3):230-6.

55. Krikos AA. Self-curing resins in constructing patterns for small castings. J Prosthet Dent. 1968 Sep;20(3):235-8.

56. Ness EM, Nicholls JI, Rubenstein JE, Smith DE. Accuracy of the acrylic resin pattern for the implant-retained prosthesis. Int J Prosthodont. 1992 Nov-Dec;5(6):542-9

57. Sorensen JA. A standardized method for determination of crown margin fidelity.J Prosthet Dent. 1990 Jul;64(1):18-24.

Annexure 1: Measurements of marginal discrepancy of inlay wax specimens which were immediately invested and cast at 50 sites.

G1c- Inlay wax, immediately invested and cast. (C1,…C10)- no of specimens,(MS 1…50)- measurement sites.

MS	G1 c1	G1 c2	G1 c3	G1 c4	G1 c5	G1 c6	G1 c7	G1 c8	G1 c9	G1 c10
1.	31	28	24.6	29.3	37.6	22.31	21.54	33.65	30.77	19.23
2.	4.6	24	26.1	22	36.9	24.62	23.08	47.12	32.31	20
3.	27	21.3	19.2	18.6	36.1	19.23	20.77	45.19	31.54	27.69
4.	16	21.3	24.6	18.6	33	19.23	21.54	47.12	33.08	23.85
5.	4	19.3	24.6	24.6	26.9	21.54	20	50	31.54	29.23
6.	10	22	22.3	29.3	20.7	30	16.92	47.12	33.85	30
7.	4.5	24.6	18.4	32	16.9	30.77	15.38	48.08	28.46	26.92
8.	22	22.6	27.6	37.3	7.6	26.93	18.46	44.23	28.46	28.46
9.	12	22.6	26.1	20	32.3	22.31	20.01	44.23	24.62	27.74
10.	4	23.3	25.3	36	35.3	26.92	18.46	34.62	23.08	30.77
11.	22.6	23.3	23.8	12	50	29.23	20.77	35.58	44.62	27.69
12.	30	22	27.6	14.6	57.6	28.46	20.77	9.23	50	22.31
13.	23.3	23.3	30.7	8.6	48.4	26.15	16.92	13.85	48.46	23.85
14.	42.6	20.6	34.6	7.3	42.3	22.31	20.77	13.85	44.62	22.31
15.	33.3	20	30	10	33	20.77	21.54	15.38	40.77	23.08
16.	36	22.6	33	10.6	36.3	24.62	19.23	16.92	37.69	21.54
17.	26	23.3	26.9	16.6	43	19.23	18.46	20	40	19.23
18.	20.6	20	24.6	16	47.6	29.23	13.85	22.31	39.23	19.23
19.	36	28.6	33	8.6	60.7	26.15	16.15	23.09	35.38	19.23
20.	41.3	27.3	21.5	9.3	40.7	16.15	14.62	24.62	44.62	20.83
21.	18	16	30	4	28.4	12.31	19.23	20	39.23	46.15
22.	14	13.3	39	20.6	32.3	11.54	15.38	15.38	36.92	45.38
23.	10	22.6	37.6	10.6	29.3	13.08	13.08	20	37.69	53.08
24.	8.6	4.6	47.6	12.6	20.7	15.38	12.31	17.69	36.15	43.85
25.	14.6	4.6	43.8	15.3	23	11.54	12.31	33.85	37.69	45.38
26.	25.3	9.3	40.7	16	22.3	13.85	12.31	35.38	36.15	41.54
27.	13.3	0	37.6	21.3	17.6	13.85	13.08	30.77	40.77	43.08
28.	10.6	17.3	36	24	28.4	16.92	14.62	33.85	40.77	33.08
29.	7.3	17.3	34	12.6	29.2	18.46	27.69	27.69	40.03	41.54
30.	9.3	20	33	21.3	27.6	15.38	26.92	24.62	44.62	46.92
31.	41.3	18.6	33.8	27.3	23.8	13.85	24.62	21.54	44.62	69.23
32.	37.3	18	31.5	42.6	27.6	15.38	13.85	21.54	36.92	68.46
33.	32	16	39.2	50.6	27.6	19.23	23.08	20	39.23	62.31
34.	36	14	37.6	42.6	24.6	48.46	16.92	18.46	34.62	59.23
35.	32.6	12	30.7	32.6	23.8	45.38	21.54	20	33.85	56.15
36.	38	12	23	30	22.3	36.92	18.46	16.94	25.38	57.69
37.	29.3	18	24.6	28	29.2	39.23	18.46	16.92	21.54	51.54
38.	34.6	12	27.6	36	26.9	37.69	18.46	15.38	33.85	52.31
39.	32	13.3	40.7	28.6	25.3	30	19.23	20	29.23	50
40.	29.3	18.6	30	28	29.2	30.77	15.38	24.62	23.85	52.31
41.	39.3	30	31.5	40	24.6	33.85	15.38	16.92	23.85	24.62
42.	41.3	22	33.8	42	21.5	35.38	16.92	19.23	37.69	32.31
43.	34	27.3	32.3	40.6	23.8	38.46	15.38	20	32.31	29.24
44.	34.6	24.6	26.1	18.6	27.6	39.23	13.85	20	39.23	25.38
45.	33.3	21.3	20.7	28	26.1	42.31	85.38	17.69	37.69	26.92
46.	30	19.3	21.5	30.6	27.6	24.62	90.77	13.08	37.7	31.54
47.	33.3	17.3	23.8	29.3	24.6	23.85	92.31	19.23	41.54	33.85
48.	33.3	26	22.3	36.6	25.3	20.77	86.15	26.92	42.31	38.47
49.	36.6	26	32.3	30	23.8	30	81.54	23.08	47.69	27.69
50.	30	17.3	33.8	34.6	26.9	35.38	66.15	21.54	51.54	28.47
total	1265.9	968.6	1500.6	1216.2	1513.8	1269.23	1300	1288.51	1827.76	1800.91
Mean of each specimen	25.3	19.3	30.012	24.3	30.276	25.3846	26	25.7702	36.5552	36.0182

Annexure 2: Measurements of marginal discrepancy for Autopolymerising resin specimens which were immediately invested and cast at 50 sites.

G2c- Autopolymerising resin, Immediately invested and cast, C(1,2,….10)- no of specimens ,MS (1..50)- measurement sites

MS	G2 c1	G2 c2	G2 c3	G2 C4	G2 c5	G2 c 6	G2 c7	G2 c8	G2 c9	G2 C10
1.	10.77	19.23	58.46	6.92	14.64	48.46	59.23	33.08	19.23	19.23
2.	12.31	24.62	53.08	11.54	7.69	41.54	56.15	32.31	19.23	19.23
3.	15.38	19.23	53.85	10	9.23	36.92	53.85	34.62	20.77	20
4.	11.54	22.31	57.69	8.46	5.38	39.23	52.31	36.93	18.46	22.31
5.	10	30	57.69	7.69	6.15	40.77	49.23	40.77	16.15	18.46
6.	14.62	22.31	58.46	13.08	4.68	39.23	52.31	33.85	20	19.23
7.	14.62	21.54	64.62	15.38	6.92	40	51.54	36.15	18.46	26.15
8.	16.92	26.93	60.77	14.62	6.15	33.08	52.31	36.15	20	27.69
9.	15.38	26.92	64.62	12.31	6.92	31.54	77.69	36.15	17.69	23.85
10.	15.38	30.77	67.69	16.92	7.69	30.77	53.85	30.77	22.31	27.69
11.	19.23	28.46	66.92	16.92	6.15	87.69	27.69	24.62	18.46	22.31
12.	15.38	26.15	66.92	19.23	9.23	91.54	24.62	26.92	17.69	30.77
13.	20	20.77	68.46	16.92	9.23	86.15	23.85	24.62	20.77	43.08
14.	12.31	29.23	53.85	17.69	6.15	86.15	25.38	29.23	20.77	43.85
15.	13.85	19.23	61.54	13.08	5.38	83.85	26.15	24.62	17.69	38.46
16.	15.38	26.15	54.62	19.23	3.85	80.77	20.77	27.69	18.46	33.85
17.	23	24.62	57.69	15.38	4.62	76.15	24.62	25.38	20	33.08
18.	20	22.31	60	19.23	3.08	70	26.15	25.38	18.46	24.62
19.	17.69	12.31	58.46	16.92	3.85	66.92	22.31	36.15	21.54	23.85
20.	17.69	29.23	65.38	26.92	7.69	53.08	33.08	36.15	46.15	16.94
21.	26.92	11.54	60.77	23.08	9.23	52.31	29.23	35.38	44.62	15.38
22.	33.85	13.08	64.62	23.08	11.54	52.31	35.38	37.69	41.54	20.77
23.	33.85	16.15	67.69	20.77	7.69	56.15	34.62	33.08	41.54	24.62
24.	34.62	13.85	65.38	27.69	22.31	59.23	41.54	34.62	38.46	22.31
25.	29.23	15.38	55.38	23.08	25.38	61.54	37.69	33.85	36.92	17.69
26.	26.92	18.46	77.69	24.62	23.85	59.23	33.85	32.31	35.38	17.69
27.	26.93	16.92	72.31	29.23	20	66.15	33.08	38.46	26.92	29.23
28.	36.15	13.85	65.38	31.54	20	64.62	36.15	37.69	29.23	23.08
29.	30.77	37.69	79.23	21.54	15.38	63.85	33.08	29.23	27.69	16.15
30.	30	15.38	67.69	19.23	11.54	66.15	30.77	28.46	26.15	16.92
31.	23.85	11.54	74.62	30	12.31	91.54	41.54	40	61.54	36.15
32.	18.46	13.85	53.85	33.11	14.62	86.15	42.31	43.08	60	33.85
33.	25.38	19.23	80	33.08	12.31	83.08	36.15	46.15	59.23	33.85
34.	28.46	15.38	76.92	36.15	10	71.54	36.15	41.54	58.46	30.77
35.	27.69	48.46	82.31	35.38	9.23	59.23	30	44.62	56.92	26.15
36.	29.23	45.38	83.85	39.23	11.54	84.62	30	38.46	49.23	21.54
37.	26.15	30	71.54	32.31	16.15	69.23	26.15	43.85	50.77	22.31
38.	25.38	39.23	78.4	28.46	19.23	62.31	23.08	42.31	53.08	22.31
39.	30.01	36.92	74.6	26.15	15.38	63.85	28.46	43.08	50	17.69
40.	33.08	33.85	56.4	26.97	17.69	61.54	24.62	38.46	53.85	13.85
41.	20.77	35.38	23.85	30.77	16.15	30.77	20	40	51.54	53.85
42.	22.31	38.46	23.08	26.15	10	23.85	26.15	39.23	47.7	49.23
43.	36.92	30.77	21.54	30.77	7.69	26.92	20.77	36.92	48.46	50
44.	21.54	39.23	23.08	30.77	17.69	26.92	20	34.62	53.08	50
45.	20.77	42.31	23.85	28.46	33.08	27.69	26.92	30	51.54	44.62
46.	16.17	30	22.31	34.62	22.31	23.85	23.08	36.15	55.39	44.62
47.	12.31	20.77	25.4	34.62	19.23	30.77	24.62	33.85	52.31	46.15
48.	14.62	23.85	28.47	31.54	7.69	28.46	20	35.38	55.38	35.38
49.	19.23	24.62	30.77	35.38	6.15	34.62	19.23	40.77	57.69	26.92
50.	24.62	35.38	20.77	29.23	31.54	22.31	27.69	37.69	63.08	24.62
total	1097.64	1269.23	2862.52	1175.45	611.59	2774.63	1705.4	1758.47	1849.99	1422.35
Mean of each specimen	21.9528	25.1304	57.2504	23.509	12.2318	55.4926	34.108	35.1694	36.9998	28.447

Annexure-3: Measurements of Marginal Discrepancy of Photopolymerizing resin specimens which were immediately invested and cast at 50 sites.

G3c- Photopolymerising resin, immediately invested and cast C(1,2….10)- no of specimens, MS (1..50)- measurement sites

MS	G3 c1	G3c2	G3 c3	G3 c4	G3 c5	G3 c6	G3 c7	G3 c8	G3 c9	G3 c10
1.	20.77	70	60.77	42.31	45.38	63.85	101.54	89.23	96.92	143.08
2.	23.85	70.77	56.15	42.31	43.85	57.69	101.54	80	99.23	146.15
3.	20.77	78.46	61.54	38.46	48.46	60.77	100.77	92.31	102.31	143.08
4.	16.92	59.23	60	41.54	46.15	59.23	97.69	90.77	106.15	162.31
5.	16.15	66.92	63.08	40	71.54	63.85	95.38	86.92	102.31	161.54
6.	20.01	76.92	64.62	32.31	74.62	59.23	96.15	92.31	96.92	154.62
7.	22.31	82.31	77.69	43.85	74.62	52.31	98.46	93.85	95.38	145.38
8.	23.08	61.54	85.38	44.62	86.92	51.54	98.46	93.08	91.54	146.15
9.	27.69	70.77	86.15	36.15	91.54	56.92	101.54	82.31	92.31	153.85
10.	33.85	71.54	84.62	36.15	84.62	53.85	103.08	82.31	97.69	145.38
11.	50.77	64.62	80.77	40.77	79.23	47.69	105.38	102.31	103.85	158.46
12.	50.77	66.92	68.46	33.85	86.92	47.69	107.69	103.08	104.62	153.85
13.	43.85	66.92	41.54	38.46	87.69	38.46	99.23	102.31	99.23	157.69
14.	51.54	82.31	47.69	38.46	72.31	42.31	96.92	94.62	113.08	158.46
15.	55.38	67.69	57.69	42.31	72.31	41.54	103.85	90.77	106.92	155.38
16.	48.46	82.31	56.15	54.62	70	43.85	96.92	90.77	112.31	153.08
17.	40	67.69	53.08	58.46	67.69	43.85	101.54	92.31	90.77	158.46
18.	37.69	73.08	58.46	50.77	66.15	42.31	93.85	90.77	88.46	160
19.	45.38	96.92	60	56.92	63.08	38.46	93.85	94.62	85.38	158.46
20.	28.46	65.38	56.92	65.38	65.38	48.46	96.92	97.69	83.08	160.77
21.	64.62	55.38	53.85	46.15	60	66.15	110	109.23	116.15	158.46
22.	63.85	57.69	48.46	40	61.54	55.38	119.23	100.77	122.31	155.38
23.	63.85	72.31	55.38	47.69	57.69	62.31	108.46	114.62	120.77	153.85
24.	70	59.23	48.46	46.15	56.15	56.15	93.08	112.31	129.23	156.15
25.	70.77	56.15	53.08	45.38	53.08	60.77	93.85	106.17	132.31	153.85
26.	64.62	16.15	50.77	30	65.38	60	108.46	109.23	122.31	154.62
27.	59.23	60	50.77	33.85	58.46	64.62	95.38	113.85	126.15	156.15
28.	61.54	20.77	51.54	52.31	57.69	54.62	96.92	110.77	119.23	151.54
29.	76.92	23.85	60	45.38	70	54.62	105.38	118.46	122.31	153.85
30.	82.31	56.15	51.54	53.08	67.69	59.23	96.92	115.38	130.77	153.85
31.	66.92	16.92	43.85	52.31	68.46	83.08	131.54	103.85	90	93.85
32.	70.77	20.77	56.92	48.47	63.85	80.77	132.31	93.85	92.31	95.38
33.	71.54	20.01	62.31	53.85	61.54	83.85	137.69	90.77	107.69	99.23
34.	66.92	50.77	60.77	56.92	73.08	81.54	117.69	100	106.92	85.38
35.	66.92	27.69	65.38	50	78.46	82.31	110	97.69	106.15	104.62
36.	73.08	50.77	66.15	37.69	80.77	77.69	117.69	95.38	100.77	104.62
37.	82.31	51.54	72.31	36.92	76.92	77.69	126.15	96.92	103.85	96.92
38.	78.46	48.46	66.92	36.92	77.69	72.31	121.54	99.23	110	103.85
39.	82.31	37.69	63.85	59.23	70.77	71.54	105.38	96.92	103.85	94.62
40.	67.69	43.85	56.16	63.08	67.69	72.31	101.54	98.46	108.46	93.08
41.	96.92	55.38	62.31	63.08	73.08	73.85	132.31	97.69	83.85	135.38
42.	72.31	40	46.15	65.38	73.08	72.31	134.62	99.23	83.85	136.92
43.	65.38	22.31	44.62	60	73.08	69.23	133.08	100	71.54	133.85
44.	67.69	45.38	44.62	68.46	70	70.77	129.23	91.54	72.31	131.54
45.	57.69	64.62	43.85	62.31	74.62	75.38	130.77	100	77.69	126.92
46.	55.38	63.85	40	38.46	69.23	66.92	133.85	86.92	73.85	120.77
47.	56.15	63.85	39.23	55.38	75.38	62.31	136.15	90	75.38	124.62
48.	56.15	28.46	44.62	57.69	66.15	68.46	133.85	91.54	83.85	126.15
49.	59.23	33.85	45.38	58.46	71.54	71.54	123.85	89.23	84.62	129.23
50.	60	23.08	43.08	40.77	66.15	60	134.62	97.69	86.15	135.38
total	2729.23	2685.23	2873.09	2383.07	3437.68	3081.57	5542.3	4870.04	5033.09	6896.16
Mean of each specimens	54.5846	53.6718	57.4618	47.6614	68.7536	61.6314	110.846	97.4008	100.6618	137.9232

Annexure -4: Measurements of marginal discrepancy of inlay wax specimens which were stored at 0^0c for 24 hours and measured before casting at 50 sites.

G1 2a(bc)- inlay wax, kept at 0^0 c for 24 hours and measured before casting.G12a (1,2…10)- no of specimens, MS(1..50)- measurement sites.

MS	G1 2a - 1(bc)	G1 2a - 2(bc)	G1 -2a- 3(bc)	G1-2a- 4(bc)	G1-2a- 5(bc)	G1-2a- 6(bc)	G1-2a- 7(bc)	G1-2a- 8(bc)	G1-2a- 9(bc)	G1-2a- 10(bc)
1.	0	6.1	0	12.3	6.15	9.23	6.92	0	0	0
2.	0	3.8	0	13	6.15	6.15	0	0	0	0
3.	0	6.1	0	10	4.62	5.38	0	0	0	0
4.	0	6.1	0	9.23	4.62	5.38	5.38	0	0	0
5.	0	0	2.3	9.23	5.38	0	0	0	0	0
6.	0	7.6	3	10.77	6.2	0	0	0	0	0
7.	6.1	0	5.3	8.46	7.69	0	5.38	0	0	0
8.	6.1	0	6.9	7.69	9.23	0	0	0	0	5.38
9.	0	3.8	9.2	9.23	6.15	0	0	0	0	4.62
10.	0	4.6	6.1	9.23	7.69	0	0	0	0	0
11.	0	0	0	9.23	12.33	3.85	10.77	0	0	0
12.	0	5.3	4.6	10	6.92	10	13.85	0	0	0
13.	0	0	0	11.54	6.15	0	13.08	0	0	0
14.	0	3.8	0	7.69	8.46	6.92	12.31	0	0	0
15.	0	3.8	22.3	8.46	5.38	0	10.77	0	0	0
16.	0	0	19.2	6.92	16.15	5.38	7.69	0	0	0
17.	0	0	18.4	6.15	14.62	4.62	9.23	0	0	0
18.	0	0	20	6.92	13.08	6.15	11.54	0	0	0
19.	0	0	20.7	20.77	6.92	0	8.46	0	0	0
20.	0	0	20	21.54	6.92	0	6.92	0	0	0
21.	0	5.3	22.3	15.38	6.15	4.62	10.88	0	0	0
22.	0	5.3	20	16.15	7.69	5.38	11.54	0	0	5.38
23.	0	4.6	18.4	13.08	6.15	0	12.31	0	0	6.15
24.	0	6.9	20	10.77	7.69	4.62	14.62	0	0	0
25.	0	0	0	12.31	6.92	0	13.08	0	0	0
26.	0	0	0	13.85	5.38	3.85	10.77	0	0	0
27.	0	0	0	14.62	7.69	3.85	12.31	0	0	0
28.	0	0	0	29.23	10	3.85	10	0	0	0
29.	0	0	5.3	22.31	8.46	4.62	10.77	0	0	0
30.	0	0	6.9	27.69	6.92	4.62	14.62	0	0	0
31.	0	0	10.7	22.31	4.62	5.38	11.54	0	3.85	0
32.	0	0	7.6	19.23	6.34	0	10.77	0	0	0
33.	0	0	6.9	20	5.38	4.62	10.77	0	4.62	0
34.	0	0	4.6	15.38	0	3.08	10.77	0	0	0
35.	0	0	19.2	13.8	0	4.62	10	0	0	0
36.	0	0	20.7	14.6	0	3.85	0	0	0	0
37.	0	0	18.4	10.7	0	3.08	0	0	0	0
38.	0	0	12.3	15.3	0	0	6.97	0	0	0
39.	0	0	7.6	13.8	0	0	12.31	0	0	0
40.	0	0	9.2	13	0	3.85	11.54	0	0	0
41.	0	0	0	11.5	0	0	6.15	0	0	0
42.	0	0	7.6	12.3	0	0	8.46	0	0	0
43.	0	0	7.6	13	0	0	5.38	0	0	0
44.	0	0	7.6	8.4	0	0	3.17	0	0	0
45.	0	0	7.6	0	0	0	3.85	0	0	0
46.	0	0	13.8	0	0	0	5.38	0	0	0
47.	0	0	8.4	0	0	0	8.46	0	0	0
48.	0	0	10	0	0	0	7.69	0	0	0
49.	0	0	0	0	0	0	7.69	0	0	0
50.	0	0	9.2	0	0	0	6.15	0	0	0
total	12.2	73.1	439.9	587.07	250.2	126.95	390.25	0	8.47	21.53
Mean of each specimens	0.244	1.462	8.798	11.7414	5.004	2.539	7.805	0	0.1694	0.4306

Annexure-5: measurements of marginal discrepancy of Autopolymerizing resin specimens which were stored at 0^0c ,for 24 hours and measured before casting at 50 sites.

G2 2a (bc)- Autopolymerising resin, kept at 0^0c for 24 hours and measured before casting. G1 2a (1,2….10)- no of specimens, MS (1…50)-measurement sites

MS	G2 2a - 1(bc)	G2 2a - 2(bc)	G2-2a-3(bc)	G2-2a-4(bc)	G2-2a-5(bc)	G2-2a-6(bc)	G2-2a-7(bc)	G2-2a-8(bc)	G2-2a-9(bc)	G2-2a-10(bc)
1.	16.9	0	0	33.85	0	17.69	0	23.85	0	10
2.	16.1	0	0	32.31	0	16.15	0	21.54	0	8.46
3.	21.5	0	0	23.86	0	18.46	0	20.77	30	16.15
4.	0	0	0	24.62	0	17.69	0	26.92	30.77	17.69
5.	23.8	0	0	21.54	0	16.92	10.77	23.85	33.85	17.69
6.	28.4	0	0	25.38	0	21.54	12.31	23.08	36.16	14.62
7.	25.3	0	0	30	0	21.54	18.46	18.46	26.92	11.54
8.	29.2	0	0	30.77	0	10.77	17.71	35.38	22.31	11.54
9.	17.6	0	0	36.92	0	8.46	16.15	33.85	26.92	0
10.	17.6	0	13.85	26.92	0	13.08	22.31	28.46	17.69	0
11.	0	0	12.31	28.46	0	27.69	26.92	10.77	6.92	0
12.	0	0	13.08	23.08	0	26.15	39.23	9.23	10.77	0
13.	0	0	11.54	19.23	0	28.46	32.31	8.46	0	0
14.	0	0	13.08	15.38	0	26.15	24.62	7.69	0	0
15.	0	0	11.54	24.62	0	30	21.54	37.69	0	10
16.	0	0	15.38	30	0	21.54	28.46	33.08	0	9.23
17.	0	0	8.46	27.69	0	25.38	27.69	30	0	16.15
18.	0	0	10	17.69	0	26.15	3.85	23.85	0	18.46
19.	0	0	10.77	25.38	0	25.38	0	26.15	0	20.77
20.	0	0	7.69	17.69	0	7.69	0	26.15	10	18.46
21.	0	0	30	22.31	40.77	13.08	0	12.31	29.23	0
22.	0	0	26.15	20	31.55	13.85	0	10	25.38	0
23.	0	0	23.08	22.31	40.77	12.31	27.69	13.08	24.62	0
24.	0	0	24.62	23.08	44.62	10.8	26.15	16.15	27.69	0
25.	0	0	23.08	20.77	46.15	10	26.15	20	28.47	0
26.	0	0	24.62	18.46	78.46	8.46	0	32.31	29.23	0
27.	0	0	23.08	23.85	41.54	7.69	0	24.62	19.23	0
28.	0	0	23.85	19.23	41.54	6.92	0	17.69	22.32	10
29.	0	0	25.4	29.23	35.39	6.15	17.69	10.03	18.48	5.38
30.	26.1	29.2	21.54	30.01	0	7.69	19.23	8.46	0	10
31.	25.3	33	22.31	24.62	0	14.62	17.69	0	0	7.69
32.	20	34.6	22.31	21.54	0	20.77	20	0	0	11.54
33.	17.6	31.5	16.92	18.46	0	22.31	17.69	0	0	21.54
34.	14.6	43	17.69	0	0	24.62	21.54	0	0	25.38
35.	14.6	26.9	13.08	0	0	25.38	24.62	0	0	29.23
36.	13	12.3	17.69	0	0	22.31	0	0	0	22.31
37.	16.9	0	16.92	0	0	21.54	0	0	0	24.62
38.	15.3	0	43.85	0	0	5.38	0	6.15	0	33.08
39.	26.1	0	44.62	0	0	5.38	8.46	6.92	0	33.08
40.	20	0	41.54	0	0	6.92	10	0	0	36.92
41.	17.6	0	40.77	0	0	12.31	13.08	11.54	0	30.78
42.	14.6	25.3	33.85	0	0	14.62	12.31	0	0	33.08
43.	14.6	19.2	32.31	0	0	11.54	11.54	0	0	33.08
44.	25.3	14.6	25.38	0	0	15.38	6.92	0	0	27.69
45.	13	15.3	30.77	0	10	14.62	8.46	0	0	30.77
46.	15.3	16.1	30.77	0	0	9.23	13.08	0	0	34.62
47.	16.9	19.2	31.54	0	0	13.08	16.15	0	0	31.54
48.	26.1	20	30	0	0	10	18.46	0	0	33.08
49.	20	20	30.77	0	0	7.69	0	0	0	33.08
50.	0	0	30.77	0	0	0	0	0	0	0
total	569.3	360.2	946.98	809.26	410.79	781.54	639.24	658.49	476.96	759.25
Mean of each specimens	11.386	7.204	18.9396	16.1852	8.2158	15.6308	12.7848	13.1698	9.5392	15.185

Annexure-6: measurements of marginal Discrepancy for photopolymerising resin specimens which were stored at 0^0c,for 24 hours and measured before casting at 50 sites.

G3 2a(bc)- Photopolymerising resin, kept at 0^0c for 24 hours and measured before casting.G3 2a(1,2…10)- no of specimens, MS(1…50)- Measurement sites

MS	G3 2a - 1(bc)	G3 2a - 2(bc)	G3-2a-3(bc)	G3-2a-4(bc)	G3-2a-5(bc)	G3-2a-6(bc)	G3-2a-7(bc)	G3-2a-8(bc)	G3-2a-9(bc)	G3-2a-10(bc)
1.	12.3	0	0	19.23	0	24.62	58.46	10.77	23.85	15.38
2.	13.8	0	0	18.46	0	26.92	60.77	10	23.08	17.69
3.	7.6	0	0	20	28.46	28.47	54.62	13.85	22.31	14.62
4.	11.5	0	0	23.08	36.15	36.15	53.08	19.23	23.85	19.25
5.	16.9	0	0	19.23	46.15	38.46	53.85	16.15	22.31	22.31
6.	13	0	0	16.92	47.69	30	46.92	0	21.54	21.54
7.	13	0	0	18.46	30	34.62	50.78	0	19.23	22.31
8.	9.2	0	13.85	23.08	40.77	15.38	51.54	0	17.69	18.46
9.	8.4	0	13.85	17.69	41.55	26.92	49.23	0	22.31	20
10.	8.4	0	13.08	20	77.69	26.92	33.85	0	16.15	14.62
11.	0	0	13.85	20.77	73.08	23.08	55.38	21.54	31.54	11.54
12.	0	0	15.38	18.46	79.23	19.23	56.15	16.15	33.08	16.15
13.	0	0	16.15	0	86.92	20	50	22.31	34.62	20.77
14.	0	0	14.62	0	83.09	17.69	51.54	18.46	34.62	14.62
15.	0	0	14.62	0	72.31	20.77	55.38	16.15	36.92	15.38
16.	0	0	13.08	0	53.08	21.54	83.08	18.46	37.69	12.31
17.	0	0	12.31	21.54	32.31	23.85	73.08	20.77	33.08	20
18.	0	0	16.92	20	49.23	23.85	67.69	22.31	39.23	16.92
19.	0	0	21.54	26.15	50	27.69	63.85	23.85	40.77	18.46
20.	0	0	19.23	18.46	46.15	28.46	62.31	14.62	41.54	11.54
21.	0	0	12.31	18.46	42.31	19.23	66.92	22.31	26.92	10.77
22.	0	0	16.92	21.54	0	18.46	66.92	25.38	26.15	8.46
23.	0	0	44.62	21.54	0	16.15	66.15	23.85	28.46	13.85
24.	0	0	42.31	20.77	0	14.62	61.54	19.23	30.77	16.92
25.	0	0	45.38	21.54	0	16.15	58.46	23.85	36.15	17.69
26.	0	0	43.85	22.31	0	13.85	54.62	24.62	33.08	16.92
27.	0	0	23.85	17.69	0	15.38	53.08	25.38	43.08	16.92
28.	0	0	20.77	12.31	0	16.92	49.23	16.92	43.85	24.62
29.	0	0	35.38	13.08	0	16.15	28.46	17.69	43.08	22.31
30.	0	0	25.38	15.38	0	15.38	0	23.08	38.46	23.08
31.	0	0	23.85	16.15	0	0	0	0	18.46	23.08
32.	0	0	24.62	13.08	0	0	0	0	19.23	15.38
33.	0	0	22.31	16.15	0	0	0	0	42.31	16.92
34.	0	0	28.46	13.85	31.54	0	0	0	37.69	13.85
35.	0	0	30.77	21.54	23.08	23.85	0	0	37.69	20.77
36.	0	0	29.23	19.23	24.62	16.15	0	0	44.62	19.23
37.	0	0	26.15	22.31	20.77	14.62	0	0	32.31	20
38.	0	0	26.15	22.31	0	16.92	0	0	30.77	21.54
39.	0	0	30.77	21.54	0	14.62	0	0	27.69	20
40.	0	0	28.46	23.85	22.31	10.77	0	0	21.54	27.69
41.	0	0	15.38	0	29.23	10	0	23.09	23.85	26.15
42.	0	0	14.62	0	39.23	9.23	0	25.38	24.62	0
43.	0	0	17.69	0	53.08	18.46	0	28.46	21.54	0
44.	0	0	18.46		42.31	15.38	0	30.77	25.38	0
45.	0	0	16.92	0	44.62	23.85	13.85	31.54	22.31	0
46.	0	0	20.77	0	0	0	16.15	25.38	25.38	0
47.	0	0	14.62	0	0	0	0	35.38	34.62	0
48.	0	0	20	0	0	0	0	26.15	32.31	0
49.	0	0	19.23	0	0	0	0	26.15	31.54	0
50.	0	0	16.92	0	0	0	0	26.15	27.69	0
total	114.1	0	954.63	696.16	1346.96	850.76	1666.94	765.38	1506.96	740.02
Mean of each specimens	2.282	0	19.0926	14.20735	26.9392	17.0152	33.3388	15.3076	30.1392	14.8004

Annexure-7: Measurements of marginal discrepancy of Inlay wax specimens which were stored at ambient temperature, for 24 hours and measured before casting at 50 sites.
G1 2b (bc)- Inlay wax, kept at ambient temperature for 24 hours and measured before casting.G12b (1,2…10)- no of specimens ,MS (1..50)- measurement sites

MS	G1 2b - 1(bc)	G1 2b - 2(bc)	G1 2b- 3(bc)	G1 2b- 4(bc)	G1 2b- 5(bc)	G1-2b- 6(bc)	G1-2b- 7(bc)	G1-2b- 8(bc)	G1-2b- 9(bc)	G1-2b- 10(bc)
1.	0	16.9	12.3	0	9.23	3.08	5.38	0	0	20
2.	0	16.9	13.8	0	7.69	4.62	6.15	0	0	21.54
3.	0	17.6	10.7	0	7.69	6.92	4.62	0	0	19.23
4.	0	20	8.4	0	7.69	6.92	3.85	0	2.31	21.54
5.	0	23	12.3	0	6.15	6.92	4.62	0	2.31	23.08
6.	0	22.3	11.5	0	0	6.15	3.85	0	3.08	18.46
7.	0	9.2	10	0	0	6.92	3.85	0	0	12.31
8.	0	10	13	0	0	3.85	10.77	0	4.62	13.08
9.	0	7.6	10	0	6.92	0	7.69	0	0	9.23
10.	0	8.4	10	0	8.5	0	4.62	0	0	4.68
11.	0	10	9.3	0	6.15	4.62	0	0	20	5.38
12.	0	8.4	9.2	0	0	5.38	0	0	18.46	5.38
13.	0	8.4	11.5	0	0	0	0	0	20.77	0
14.	0	6.4	11.5	0	0	0	0	0	17.69	0
15.	7.6	13.8	11.5	0	0	8.46	0	0	19.23	0
16.	10	10	11.5	0	0	4.62	0	0	19.23	5.38
17.	4.6	10	8.4	0	0	6.15	0	0	14.62	4.68
18.	3.8	11.5	13	0	0	5.38	0	0	13.85	5.38
19.	3	7.6	16.1	0	3.85	3.08	0	0	6.15	3.85
20.	70.7	6.5	14.6	0	5.38	3.08	0	0	3.85	7.69
21.	70.7	0	9.2	0	9.23	4.62	0	0	7.69	4.62
22.	68.3	0	9.2	0	6.15	0	3.85	3.08	6.2	3.85
23.	83	0	8.1	0	7.69	0	6.15	9.23	8.46	2.31
24.	40	0	9.2	3.85	0	0	0	10	10	5.38
25.	38	6.9	5.3	3.85	6.97	8.46	0	8.5	10	2.31
26.	46.5	6.9	0	3.92	0	0	0	7.69	6.15	3.85
27.	55.3	13	13	4.68	0	0	0	5.38	6.15	3.08
28.	56.9	10.3	9.2	0	0	0	0	0	0	3.08
29.	56.9	6.9	5.3	0	0	0	0	0	0	5.38
30.	40.3	7.6	13	7.69	0	8.46	0	0	0	6.15
31.	51.5	9.2	9.2	4.62	0	6.92	0	0	7.69	0
32.	76.1	20	7.6	5.44	0	3.08	6.92	0	8.46	0
33.	70.7	21.5	10.7	0	0	0	8.46	0	9.23	0
34.	69.2	20	10.7	0	0	4.62	8.46	0	10	4.62
35.	49.2	25.4	0	0	10.03	3.85	9.23	0	7.69	0
36.	53.8	15.3	0	3.85	10	0	7.69	0	5.38	3.08
37.	56.9	13.8	10	4.62	10.77	0	12.31	0	0	0
38.	73.8	13.8	9.2	12.31	9.23	6.2	8.46	0	0	0
39.	46.9	12.3	7.7	7.69	9.23	6.2	8.46	0	3.85	0
40.	0	0	10.7	0	9.23	0	5.38	0	5.38	3.85
41.	0	0	0	0	0	3.08	0	0	3.08	0
42.	0	0	0	0	0	2.31	9.23	0	6.15	0
43.	0	0	10	0	0	3.85	10	0	6.92	0
44.	10.3	0	9.2	0	10	3.85	8.46	0	6.92	6.15
45.	8.4	0	7.7	0	9.23	4.62	6.15	0	7.69	5.44
46.	4.6	0	10.7	0	8.46	0	7.69	0	0	4.62
47.	4.6	0	0	0	9.23	0	9.23	0	0	3.85
48.	4.6	0	0	0	10.77	3.08	10	0	0	5.38
49.	4.6	0	4.6	0	10.77	8.46	6.15	0	5.38	0
50.	0	0	10.7	0	0	10	0	0	4.62	0
total	1240.8	447.4	438.8	62.52	216.24	177.81	207.68	43.88	319.26	277.89
Mean of each specimens	24.816	8.948	8.776	1.2504	4.3248	3.5562	4.1536	0.8776	6.3852	5.5578

Annexure-8: measurements of marginal Discrepancy of Autopolymerising resin specimens which were stored for 24 hours, at ambient temperature and measured before casting at 50 sites.

G2 2b (bc)- Autopolymerising resin kept at ambient temperature for 24 hours and measured before casting.G2 2b(1,2,…10)- no of specimens, MS (1..50)- measurement sites.

MS	G2 2b-1(bc)	G2 2b 2(bc)	G2 2b-3(bc)	G2 2b-4(bc)	G2 2b-5(bc)	G2-2b-6(bc)	G2-2b-7(bc)	G2-2b-8(bc)	G2-2b-9(bc)	G2-2b-10(bc)
1.	0	0	16.15	9.23	45.38	16.15	0	7.69	36.92	31.54
2.	0	0	11.54	9.23	48.46	18.46	0	8.46	43.08	31.54
3.	0	0	9.23	12.31	46.15	13.08	0	10.77	38.46	34.62
4.	0	0	7.69	13.08	0	9.23	0	7.69	42.31	32.31
5.	32.3	0	7.69	9.23	0	12.31	0	8.46	43.85	11.54
6.	30.7	0	6.92	9.23	0	7.69	6.15	9.23	53.85	17.69
7.	42.3	0	5.38	4.62	0	8.46	6.15	10	50	18.46
8.	10.7	0	8.46	9.26	66.92	7.69	3.85	23.08	50	20.77
9.	25.3	0	10	0	60.77	7.69	4.62	18.46	43.08	11.54
10.	0	0	0	0	29.23	10	7.69	20.77	36.15	8.46
11.	0	0	0	0	26.17	0	21.54	0	46.15	13.85
12.	26.9	0	0	6.15	24.63	0	31.54	0	43.08	0
13.	25.3	0	12.31	0	25.38	0	26.92	0	44.62	0
14.	26.9	0	10.77	0	33.85	0	23.85	0	45.38	0
15.	30	0	7.09	0	31.54	0	22.31	0	42.31	0
16.	24.6	0	10.77	19.23	35.39	0	23.08	0	43.08	0
17.	23.8	0	10.77	0	37.7	0	26.92	0	43.08	0
18.	30	0	34.62	16.15	40.77	0	27.69	0	43.08	0
19.	21.5	0	0	16.92	40.77	24.62	25.38	0	34.62	0
20.	0	29.7	0	15.4	0	24.62	0	0	30.77	0
21.	0	0	0	10	0	10	6.92	20	18.46	0
22.	0	46.1	0	0	32.31	8.46	12.31	18.46	16.92	21.54
23.	36.9	25.3	0	0	28.47	8.46	16.15	20.77	23.08	17.69
24.	25.3	24.6	0	0	17.69	0	20	18.46	23.85	21.54
25.	41.5	12.3	0	6.15	21.54	0	19.23	16.92	22.31	17.69
26.	29.2	41.5	0	10.77	22.31	0	17.69	16.92	23.08	20
27.	15.3	34.6	0	11.56	17.71	0	18.46	17.69	26.15	0
28.	0	36.9	0	36.16	0	0	16.92	18.46	22.31	0
29.	26.9	37.6	0	0	0	0	13.08	0	24.62	0
30.	0	12.3	0	0	0	0	16.92	0	24.62	0
31.	31.5	40.7	0	7.69	0	6.34	0	0	26.15	0
32.	26.1	20.7	0	0	0	3.08	0	0	30	0
33.	13	16.1	0	0	0	6.15	0	0	30.77	0
34.	18.4	10.7	0	11.54	0	6.15	0	0	29.23	0
35.	13	51.5	0	15.38	0	7.69	0	0	31.54	0
36.	13.8	34.6	0	15.38	0	7.69	0	6.15	26.15	0
37.	23	70.7	0	14.62	0	0	0	9.23	26.92	0
38.	26.1	60	0	20	0	0	11.54	10.77	25.38	0
39.	20	37.6	0	15.38	0	10	13.08	10.77	26.15	0
40.	37.6	11.5	0	12.31	0	11.54	0	10.77	27.69	0
41.	30	16.1	0	17.69	7.69	13.08	11.54	36.15	0	0
42.	25.3	20	12.31	13.1	8.46	16.92	15.38	36.92	0	27.69
43.	0	17.6	10	13.08	20.78	14.62	15.38	39.24	0	25.38
44.	26.9	25.3	13.85	13.08	30.81	13.08	13.85	41.54	0	27.69
45.	22.3	0	16.15	11.54	0	10.03	20.77	49.23	0	27.69
46.	19.2	0	16.15	0	0	0	10	39.23	0	32.31
47.	24.6	0	15.38	0	0	0	8.46	37.69	0	26.92
48.	28.4	0	20.77	19.25	0	0	8.46	37.69	0	18.46
49.	28.4	0	20.77	0	60.7	0	8.46	36.15	0	13.08
50.	0	0	21.54	0	0	0	0	0	0	5.38
total	953	734	316.31	424.72	861.58	313.29	552.29	673.82	1359.25	535.38
Mean of each specimen	19.06	14.06	6.3262	8.4944	17.2316	6.2658	11.0458	13.4764	27.185	10.7076

Annexure 9: Measurements of Marginal discrepancy for photopolymerising resin specimens which were stored for 24 hours at ambient temperature and measured before casting at 50 sites

G3 2b (bc)- Photopolymerising resin kept at ambient temperature for 24 hours and measured before casting G3 2b(1,2,3….10)- no of specimens,MS (1…50)- measurement sites

MS	G3 2b - 1(bc)	G3 2b - 2(bc)	G3 2b-3(bc)	G3 2b-4(bc)	G3 2b-5(bc)	G3-2b-6(bc)	G3-2b-7(bc)	G3-2b-8(bc)	G3-2b-9(bc)	G3-2b-10(bc)
1.	21.5	28.4	0	12.33	23.85	0	30	0	21.54	23.08
2.	20	23.8	0	8.46	18.46	0	30	0	16.92	23.85
3.	23	25.3	0	10	19.23	0	33.85	0	17.69	13.08
4.	23	23	0	15.38	24.62	0	29.23	0	17.69	0
5.	30	23	24.62	8.46	21.54	13.08	35.38	0	20.77	0
6.	28.4	30	22.31	8.46	20	13.08	34.62	0	19.23	26.92
7.	34.6	27.6	0	11.54	20.01	13.85	9.23	0	20	27.69
8.	33	21	0	6.92	14.64	11.54	10.77	0	16.15	27.69
9.	38.4	22.3	0	7.69	15.4	15.38	0	0	11.54	30.77
10.	38.4	16.9	18.46	0	0	26.17	0	0	21.55	27.69
11.	39.2	16.9	23.85	0	0	24.62	0	30.77	21.54	9.23
12.	36.1	0	21.54	0	0	22.31	0	30	22.31	9.23
13.	25.3	0	17.69	0	0	23.08	17.69	24.62	39.23	16.15
14.	27.6	0	19.23	0	13.08	28.46	22.31	27.69	28.46	23.08
15.	30.7	0	18.48	0	12.31	29.23	31.54	24.62	28.46	24.62
16.	32.3	0	18.48	0	13.85	32.31	40.77	25.38	30	23.85
17.	36.9	11.5	0	0	20.01	32.31	34.62	23.08	24.62	24.62
18.	33.8	13.8	0	0	16.94	29.23	26.92	21.55	11.54	23.85
19.	31.5	14.6	0	0	13.08	23.85	24.62	23.08	0	27.69
20.	36.9	8.4	0	0	4.62	0	23.85	0	0	21.54
21.	36.9	10.7	37.69	0	20.01	0	24.62	27.69	0	34.62
22.	38.4	7.6	37.7	0	0	0	25.38	29.23	0	40.77
23.	34.6	30.7	36.92	0	0	0	23.08	30.77	0	46.92
24.	30	31.5	32.31	0	0	0	16.15	31.54	13.08	45.38
25.	12.3	16.9	29.23	0	14.62	0	26.15	26.92	0	55.38
26.	15.3	19.2	26.92	0	16.15	0	38.46	26.92	0	53.85
27.	13.8	43	29.23	0	20.01	0	26.15	24.62	0	50.77
28.	22.3	18.4	31.54	0	21.54	0	47.69	25.38	0	50
29.	18.4	30	32.32	0	19.23	0	31.54	18.46	0	50.77
30.	26.9	29.2	18.46	0	19.29	0	30	24.62	0	51.54
31.	33.8	20	20.01	0	19.25	0	34.62	23.08	0	24.62
32.	30.7	20.7	19.25	0	17.71	0	30.77	23.08	0	19.25
33.	26.1	12.3	40.77	0	9.23	0	30	22.31	0	26.15
34.	23	21.5	42.31	0	12.33	0	28.46	25.38	0	24.62
35.	21	23	37.69	0	10.8	0	22.31	20.77	0	29.23
36.	24.6	16.1	39.23	0	11.56	0	26.15	20.77	0	30.01
37.	25.3	20.7	41.54	0	12.31	0	27.69	25.38	0	28.46
38.	26.9	0	39.23	0	17.69	0	38.46	24.62	0	30.01
39.	24.6	25.3	40	0	33.08	0	26.92	25.38	0	44.62
40.	23.8	16.1	43.85	0	32.32	0	26.15	23.08	33.85	46.92
41.	0	16.9	42.31	16.15	0	0	22.31	24.62	33.85	20.77
42.	0	15.3	33.08	20	0	0	23.08	27.69	36.92	22.31
43.	0	11.5	33.08	17.71	0	0	22.31	28.46	33.08	22.31
44.	16.1	13	0	20.77	0	0	23.85	28.46	32.31	19.23
45.	13.8	9.2	0	16.92	0	0	25.38	0	36.15	23.13
46.	12.3	13	34.62	14.62	0	0	24.62	0	35.42	21.54
47.	8.4	10	33.85	13.08	0	0	25.38	0	40	20.77
48.	11.5	36	38.46	12.31	0	0	22.31	0	33.08	13.85
49.	9.2	36	40.78	20.01	0	0	26.15	0	0	17.69
50.	12.3	0	32.31	22.32	0	0	23.08	0	0	15.38
total	1212.9	880.3	1149.35	263.13	578.77	338.5	1254.62	840.02	716.98	1385.5
Mean of each specimen	24.25	17.6	22.987	5.2626	11.5754	6.77	25.0924	16.8004	14.3396	27.71

Annexure 10: measurements of marginal discrepancy of inlay wax specimens which were stored for 24 hours, at 0^0c and measured after casting at 50 sites.

G1 2a(ac) – inlay wax, kept at 0^0c for 24 hours and measured after casting 2a(1,2…10)- no of specimens,MS (1…50)- measurement sites

MS	G1 2a 1 ac	G1 2a 2 ac	G1 2a 3 ac	G1 2a 4 ac	G1 2a 5ac	G1-2a-6 ac	G1-2a-7 ac	G1-2a-8 ac	G1-2a-9 ac	G1-2a-10 ac
1.	4.62	30.77	10.8	23.85	10.8	46.92	20	36.92	73.08	8.46
2.	3.08	20.77	18.46	31.55	14.62	39.23	20	45.38	73.85	6.92
3.	5.38	20.77	14.62	30.77	12.31	38.46	18.46	43.85	68.46	7.69
4.	4.62	16.92	13.08	24.62	16.15	40.77	17.69	43.85	66.92	4.62
5.	4.62	16.15	12.31	26.15	13.08	39.23	22.32	42.31	63.85	0
6.	6.92	13.85	13.08	26.15	18.46	37.69	16.92	43.08	62.31	0
7.	6.15	12.33	16.15	30	13.08	42.31	13.85	44.62	58.46	0
8.	8.46	12.31	13.08	26.15	10	36.92	15.38	41.54	58.47	4.62
9.	6.15	10.77	10	28.47	20.77	38.46	20.83	46.15	60	10
10.	4.62	9.23	8.46	26.17	13.08	37.69	21.54	42.31	55.38	10.77
11.	5.38	12.31	6.15	26.17	16.17	43.85	0	51.54	73.85	17.69
12.	6.15	14.62	10.77	25.38	11.54	45.38	0	46.92	76.92	20.77
13.	8.46	13.08	13.85	25.38	23.85	51.54	0	42.31	74.62	22.31
14.	5.38	11.54	15.38	26.15	8.46	55.38	0	36.15	83.08	20.01
15.	8.46	11.54	16.92	32.32	20.77	56.92	49.23	37.69	79.23	17.69
16.	6.15	8.46	20.77	28.46	14.64	55.38	46.15	32.31	93.85	19.23
17.	17.69	11.54	20.77	13.1	6.15	59.23	51.54	39.23	88.46	13.85
18.	13.85	7.69	16.17	13.08	25.38	64.62	44.62	37.69	77.69	14.62
19.	14.62	7.69	14.64	13.85	29.24	64.62	41.54	32.31	64.62	13.85
20.	15.38	11.54	11.54	14.62	10.77	63.08	37.69	31.54	40.77	0
21.	14.62	9.23	25.38	13.08	29.23	32.32	36.15	33.85	44.62	0
22.	14.62	17.69	21.54	12.33	43.85	35.39	27.69	34.62	49.23	0
23.	13.08	22.31	23.85	15.38	13.85	32.31	21.54	25.38	44.62	15.38
24.	13.08	23.09	29.24	23.08	28.46	23.08	22.31	42.31	44.62	21.54
25.	9.23	24.63	28.46	25.38	15.38	28.46	76.92	43.08	42.31	16.92
26.	7.69	23.08	29.23	25.4	43.08	24.62	66.92	37.69	49.23	13.85
27.	6.15	20	43.08	23.86	21.54	26.15	62.31	38.46	43.08	14.62
28.	7.69	32.32	43.85	30.77	16.92	40.77	66.92	34.62	44.62	10.8
29.	6.15	31.54	43.08	21.54	41.54	38.46	56.15	34.62	52.31	6.92
30.	7.69	30.77	41.54	16.15	40	44.62	62.31	33.09	51.54	10
31.	19.23	33.85	40	19.23	16.15	29.23	60.77	25.38	33.08	8.46
32.	20	33.09	40	16.92	11.54	24.62	60.77	26.15	33.08	8.46
33.	15.38	34.62	38.46	45.38	10.77	21.54	57.69	26.15	24.62	21.54
34.	19.25	31.55	16.15	47.69	16.92	22.31	63.85	30.77	32.31	24.62
35.	20	10.77	20	44.62	40	21.54	43.85	27.69	33.08	21.54
36.	22.31	7.69	11.54	33.11	43.08	21.54	46.92	36.93	32.31	24.62
37.	20	10.77	9.23	33.09	9.23	24.62	50	44.62	32.31	26.15
38.	17.69	12.31	10.77	31.54	18.46	19.23	55.38	47.69	33.85	28.46
39.	19.23	10	13.08	30.78	18.46	20.77	53.08	46.92	28.46	26.92
40.	20.77	13.08	18.48	38.47	20	20	48.46	40.77	27.7	21.54
41.	0	10	30.77	33.85	38.46	41.54	50.77	39.23	43.85	22.31
42.	0	13.08	6.92	11.54	17.69	36.15	56.15	40	40	21.54
43.	0	14.62	15.38	16.92	20.77	33.85	53.08	43.85	42.31	34.62
44.	0	12.31	19.23	12.31	19.23	36.92	18.46	46.92	35.38	30.77
45.	21.54	16.15	18.46	12.31	13.08	35.38	18.48	48.46	27.69	26.92
46.	20	0	20.77	17.69	6.92	32.31	15.38	49.23	29.24	27.69
47.	7.69	0	18.46	10	30.77	35.38	17.76	38.46	24.62	20.77
48.	6.92	0	17.69	13.85	15.38	34.62	19.23	41.54	25.38	20
49.	8.46	4.62	18.46	6.15	18.48	30.77	17.69	24.62	28.46	15.38
50.	13.85	0	16.92	6.15	18.46	33.08	17.69	29.23	21.54	36.15
total	528.46	777.05	1007.02	1180.96	1079.02	1859.26	1782.44	1930.03	2489.32	791.59
Mean of each specimens	10.5692	15.541	20.1404	23.6192	21.1365	37.1852	35.6488	38.6006	49.7864	15.8318

Annexure-11: measurements of marginal discrepancy of Autopolymerizing resin specimens which were stored at 0^0c for 24 hours ,and measured after casting at 50 sites.

G2 2a (ac)-Autopolymerising resin, kept at 0^0c for 24 hours measured after casting.G2 2a (1,2…10)-no of specimens, MS (1..50)-measurement sites.

MS	G2 2a 1 ac	G2 2a 2 ac	G2 2a 3 ac	G2 2a 4 ac	G2 2a 5 ac	G2-2a-6ac	G2-2a-7ac	G2-2a-8ac	G2-2a-9ac	G2-2a-10ac
1.	34.62	11.54	58.46	33.08	48.46	0	166.92	40.77	10	55.38
2.	38.46	10	59.23	50.78	47.69	0	109.23	43.08	11.54	50
3.	46.15	13.85	56.92	50.01	53.08	0	109.23	41.54	13.85	47.69
4.	43.08	11.54	52.31	43.08	60.77	0	115.38	41.54	11.54	52.31
5.	44.62	11.54	54.62	55.43	50.77	0	116.92	43.08	13.85	50.77
6.	43.85	13.85	48.46	52.31	53.85	0	116.92	44.62	11.54	36.92
7.	43.85	12.31	51.54	51.54	64.62	0	126.92	46.92	7.73	34.62
8.	42.31	7.73	55.38	55.38	60	0	126.15	49.24	12.31	46.92
9.	46.92	13.08	45.38	55.38	52.31	0	139.23	46.15	10.77	43.08
10.	40.83	50.77	55.39	82.31	65.38	46.92	146.15	59.23	13.08	36.15
11.	34.62	10.77	60.77	80.77	44.62	47.69	12.31	16.15	50.77	66.15
12.	23.08	46.92	46.15	85.38	66.15	49.23	15.38	19.23	48.46	57.69
13.	16.94	46.15	56.92	79.23	65.38	41.54	18.46	0	46.15	55.38
14.	23.85	48.46	50.01	80	58.46	43.08	20	0	45.38	47.69
15.	30.09	42.31	47.7	68.46	58.46	41.54	19.23	0	46.92	55.38
16.	44.62	45.38	54.62	74.1	50	43.85	19.23	0	42.31	46.92
17.	43.85	44.62	50.77	71.54	42.31	42.31	21.54	26.15	44.62	50.77
18.	33.85	32.31	54.62	69.23	44.62	40.77	16.92	28.46	37.69	52.31
19.	38.47	33.85	53.85	71.54	99.23	34.62	26.15	33.09	32.31	46.15
20.	26.92	33.08	53.08	86.93	113.85	14.62	26.92	36.92	33.08	41.54
21.	34.62	37.69	61.54	85.38	108.46	21.54	36.92	37.69	33.85	60
22.	34.62	38.46	57.69	78.46	98.46	20.78	41.54	36.92	30	65.38
23.	34.62	30	54.62	91.54	142.31	24.62	40	35.38	35.38	63.08
24.	29.24	40	52.31	74.62	81.54	18.46	41.54	33.08	36.15	63.08
25.	34.65	36.15	50.01	56.94	73.85	16.15	44.62	32.31	40	60
26.	23.85	35.38	53.85	60	57.69	15.38	38.46	32.31	40.77	63.85
27.	44.62	40.77	47.69	78.46	57.69	19.23	41.54	29.23	38.46	63.85
28.	52.31	29.23	46.16	54.64	50.77	30	40.77	24.62	30	33.08
29.	32.31	35.38	43.85	96.15	46.92	32.31	33.85	23.85	29.23	40
30.	33.09	30	50.77	93.85	46.15	23.85	39.23	26.15	35.38	45.38
31.	27.69	20	44.62	98.46	57.7	26.15	33.08	23.08	20	43.08
32.	32.32	16.92	40.83	100	38.46	26.15	31.54	22.31	16.92	41.54
33.	36.93	18.46	43.87	108.46	40	20.77	31.54	76.92	18.46	46.15
34.	31.54	20.77	40.78	79.23	44.62	25.38	35.38	80.77	20.77	48.46
35.	43.87	23.85	30.01	96.92	60.77	26.92	38.46	74.62	20.77	49.23
36.	40	18.46	30.77	111.55	70.77	30.78	36.15	73.08	18.46	50
37.	40.78	24.62	30.78	96.15	70.77	33.08	36.92	72.31	23.85	52.31
38.	49.23	20.77	21.54	120.77	61.54	34.62	30	71.54	24.62	50.77
39.	17.69	23.85	25.38	36.15	52.31	28.46	29.23	63.08	20	47.69
40.	22.31	25.38	23.85	66.15	51.54	23.85	35.38	48.46	18.46	73.85
41.	18.53	26.92	22.36	48.46	36.15	30.78	33.08	46.92	20	58.46
42.	17.69	25.4	20.77	46.92	37.69	23.08	34.62	48.46	21.54	62.31
43.	31.54	18.46	16.92	38.46	38.46	32.32	30	50	26.92	53.85
44.	37.69	30.77	24.62	62.31	36.15	23.85	34.62	51.54	25.38	57.7
45.	33.11	20	29.23	67.69	36.92	24.62	36.15	58.46	30.77	46.92
46.	58.46	33.85	33.08	80	33.85	22.31	38.46	50.77	31.54	37.7
47.	47.7	20	30	72.31	0	26.15	35.38	56.93	31.54	40
48.	40.77	31.54	48.46	83.85	0	23.85	30.77	70.77	33.85	31.54
49.	40.77	31.54	47.7	79.23	0	23.08	26.92	89.23	25.4	26.15
50.	40.77	21.54	49.25	37.69	0	0	35.38	76.15	23.85	58.46
total	1804.3	1359.22	2239.49	3597.28	2731.55	1174.69	2540.72	2133.11	1366.22	2507.69
Mean of each specimens	36.086	27.1654	44.7898	71.9456	54.631	23.4938	50.8144	42.6622	27.3244	50.1538

Annexure-12: measurements of marginal discrepancy of photopolymerising resin stored at 0^0c for 24 hours and measured after casting at 50 sites.

G3 2a (ac)- photopolymerising resin kept at 0^0c for 24 hours and measured after casting.G3 2a (1,2,…10)-no of specimens, MS (1..50)-measurement sites.

MS	G3 2a 1 ac	G3 2a 2 ac	G3 2a 3 ac	G3 2a 4 ac	G3 2a 5 ac	G3-2a-6ac	G3-2a-7ac	G3-2a-8ac	G3-2a-9ac	G3-2a-10ac
1.	71.54	18.46	114.62	70	83.08	60.77	80.77	43.85	160	135.38
2.	73.08	12.31	113.08	79.23	84.62	56.92	86.92	40	157.69	135.38
3.	70	15.38	122.31	81.54	90	52.31	65.38	44.62	144.62	130
4.	76.15	14.62	128.46	91.54	82.31	50.77	66.15	44.62	143.08	127.69
5.	56.15	16.15	112.31	90.77	84.62	52.31	54.62	46.15	170	134.62
6.	65.39	19.23	105.38	79.23	81.54	49.23	48.46	52.31	175.38	113.08
7.	65.38	28.46	115.38	83.08	82.31	45.38	51.54	47.69	171.54	117.69
8.	57.69	32.31	134.62	86.15	76.92	52.31	64.62	48.46	170.77	115.38
9.	55.38	34.62	116.15	84.62	81.54	77.69	58.46	41.54	158.46	109.23
10.	55.38	35.38	106.15	86.15	85.39	62.31	53.08	42.31	159.23	109.23
11.	63.85	36.92	93.85	64.62	91.54	40.77	126.92	37.7	109.23	93.08
12.	45.38	34.62	70.77	72.31	89.23	46.15	123.08	33.85	114.62	98.46
13.	57.69	30	83.08	75.38	90	40	123.85	34.62	111.54	107.69
14.	62.31	30	80	79.23	93.85	50.77	116.15	35.38	116.92	115.38
15.	57.69	28.46	69.23	82.31	93.08	50	106.15	40	118.46	102.31
16.	60.77	53.85	90	49.23	83.08	39.23	108.46	40.77	117.69	107.69
17.	63.85	61.54	83.08	56.92	91.54	39.23	118.46	46.15	125.38	110
18.	69.23	53.85	86.15	53.85	94.62	42.31	116.15	40.77	120.77	104.62
19.	62.31	53.85	89.23	66.15	97.69	41.54	106.15	43.08	112.31	107.69
20.	63.08	56.15	111.54	70.77	93.85	42.31	105.38	40.77	110.77	107.69
21.	57.69	45.38	113.08	69.23	102.31	62.31	162.31	47.69	95.38	53.85
22.	66.15	43.08	83.85	69.23	119.23	63.85	160.77	33.85	94.62	56.15
23.	66.15	47.69	87.69	60.77	124.62	62.31	160	42.31	89.23	56.15
24.	46.92	38.46	90.77	79.23	129.23	61.54	150.77	36.92	90	57.69
25.	54.62	44.62	84.62	51.54	120.77	63.08	153.85	41.54	103.08	61.54
26.	61.54	43.08	90	40.77	99.23	63.85	160.77	39.26	97.69	70
27.	60	33.08	81.54	71.54	81.54	56.92	163.85	40	96.92	70.77
28.	46.15	46.15	80	78.46	71.54	67.69	158.46	39.23	103.85	61.54
29.	59.23	50.77	66.15	78.46	65.38	57.69	146.15	36.15	99.23	73.08
30.	70.77	65.38	71.54	80.77	73.08	56.92	159.23	36.92	100	67.69
31.	74.62	60.77	94.62	86.92	79.23	67.69	112.31	59.23	146.92	129.23
32.	69.23	48.46	91.54	50	86.92	56.15	86.92	66.92	132.31	131.54
33.	51.54	43.08	87.69	70	87.69	61.54	65.38	62.31	125.38	133.85
34.	57.69	23.08	97.69	58.46	89.23	59.23	61.54	65.38	125.38	133.85
35.	53.85	35.38	106.15	50.77	77.69	63.08	56.92	63.08	118.46	127.69
36.	54.62	33.08	107.69	48.46	76.15	62.31	50.77	53.85	127.69	127.69
37.	50.77	50.77	82.31	143.08	89.23	73.85	52.31	53.85	119.23	111.55
38.	51.54	46.92	77.69	144.62	73.85	70.77	112.31	50.77	115.38	115.38
39.	51.54	53.85	71.54	110.77	56.92	73.08	83.08	46.15	107.69	127.69
40.	53.08	20	116.92	114.62	66.15	76.15	53.85	51.54	148.46	126.92
41.	55.38	9.23	108.46	119.23	70	53.85	147.69	49.23	130	80
42.	56.15	13.08	110.77	114.62	72.31	55.38	153.08	48.46	125.38	84.62
43.	50.02	9.23	106.15	103.08	78.46	56.15	150	45.38	123.85	86.15
44.	50	0	102.31	111.54	75.38	53.08	156.15	53.85	123.85	86.92
45.	50.77	0	104.62	100.77	79.23	55.38	156.92	48.46	130	86.15
46.	65.38	0	97.69	136.15	85.38	53.85	156.92	46.15	123.08	92.31
47.	63.08	22.31	102.31	145.38	94.62	46.92	160	44.62	124.62	91.54
48.	55.38	34.62	104.62	146.16	89.23	46.92	163.08	42.31	136.15	76.92
49.	41.54	34.62	115.39	134.62	96.92	71.54	153.85	38.46	149.23	81.54
50.	30	33.85	109.23	140	83.85	70	149.23	50	150.77	88.46
total	2927.7	1696.18	4870.02	4312.33	4346.18	2835.39	5639.22	2278.51	6322.29	5030.75
Mean of each specimen	58.554	33.9236	97.4004	86.2466	86.9236	56.7078	112.7844	45.5702	126.4458	100.615

Annexure-13:Measurements of marginal discrepancy for inlay wax specimens stored for 24 hours at ambient temperature and measured after casting at 50 sites.

G1-2b-ac-Inaly wax, kept at ambient temperature for 24 hours and measured after casting.G1 2b (1,2…10)- no of specimens,MS (1…50)-measurement sites.

MS	G1 2b 1 ac	G1 2b 2 ac	G1 2b 3 ac	G1 2b 4 ac	G1 2b 5 ac	G1-2b-6 ac	G1-2b-7 ac	G1-2b-8ac	G1-2b-9ac	G1-2b-10 ac
1.	21.54	53.08	20.78	18.46	47.69	20.78	15.38	40	17.69	0
2.	21.54	57.69	15.38	18.46	54.62	13.93	13.85	40	20	0
3.	22.31	52.31	8.46	22.32	52.31	15.38	15.38	37.69	20	0
4.	18.46	53.85	15.38	19.23	49.23	13.85	16.92	40	20.77	0
5.	18.46	46.92	13.93	23.08	39.23	8.46	16.92	35.38	19.23	0
6.	19.23	51.54	14.62	22.31	46.15	13.08	18.46	33.85	26.15	0
7.	24.62	52.31	13.08	21.54	46.15	15.38	13.85	33.08	28.46	0
8.	15.38	51.54	13.85	23.85	46.15	13.85	19.23	26.15	24.62	0
9.	23.85	53.85	17.69	20	43.85	10.77	21.54	25.38	26.92	0
10.	20.78	53.85	13.85	20	41.54	14.62	24.62	20.01	23.85	0
11.	22.31	58.46	19.23	13.85	44.62	19.23	22.31	64.62	10.77	12.31
12.	16.94	53.08	10.77	19.23	43.85	17.69	23.85	60	11.54	7.69
13.	16.92	45.38	13.85	23.08	42.31	16.15	22.31	63.08	10	6.15
14.	23.86	44.62	15.38	26.15	46.92	15.38	23.08	63.08	9.23	11.54
15.	24.62	33.08	17.69	26.15	46.92	17.69	27.69	59.23	15.38	6.92
16.	22.31	46.15	16.15	23.85	46.92	13.85	23.08	63.08	17.69	0
17.	20.77	51.54	15.38	19.23	46.92	15.38	20.77	60.77	13.08	0
18.	20	48.46	10	8.46	51.54	10	16.92	61.54	42.31	0
19.	23.85	58.46	10	6.92	47.69	10	16.17	56.92	39.23	0
20.	24.62	56.15	6.92	11.54	25.38	11.54	14.62	56.92	38.46	11.54
21.	25.38	55.38	11.54	16.15	36.15	6.92	15.38	17.69	32.31	13.08
22.	50	62.31	10	10.77	33.85	8.46	18.46	30	33.85	14.62
23.	48.46	56.15	11.54	14.62	29.23	10	20.77	23.08	34.62	12.31
24.	49.23	61.54	8.46	12.31	33.85	11.54	15.38	26.15	28.46	7.69
25.	49.23	51.54	30	9.23	29.23	12.31	21.54	26.92	24.62	10
26.	44.62	53.08	44.62	8.46	30.77	11.54	16.92	26.92	33.08	10
27.	42.31	47.69	32.31	6.92	34.62	10.77	18.46	28.46	40	6.92
28.	35.38	56.15	46.15	10	26.92	13.08	18.46	30.77	28.46	9.23
29.	27.69	45.38	40	7.69	29.23	13.08	14.62	30	23.85	10.77
30.	25.38	50	50.77	9.23	29.23	11.54	17.69	33.85	30	39.23
31.	23.09	51.54	22.32	13.08	29.23	53.08	11.54	25.38	34.62	37.69
32.	23.08	52.31	52.31	13.08	24.62	59.23	16.15	21.54	36.15	37.69
33.	25.38	18.46	26.15	14.62	24.62	54.62	18.46	23.08	36.92	43.08
34.	30	21.54	54.62	16.92	27.69	50.77	20	21.54	33.08	37.69
35.	28.46	19.23	22.31	13.08	30	52.31	18.46	23.85	40.77	35.38
36.	32.31	27.69	11.54	15.38	33.08	44.62	19.23	20	40	34.62
37.	30.77	29.23	26.15	15.38	39.23	46.15	16.92	22.31	36.15	31.54
38.	30	26.15	10.77	16.17	37.69	46.15	13.08	19.23	36.15	26.92
39.	33.08	26.15	23.08	12.31	34.62	41.54	18.46	22.31	36.15	52.31
40.	27.69	29.24	59.23	14.62	33.08	24.62	14.62	14.62	12.31	47.69
41.	33.08	23.08	20	10	33.08	20	14.62	15.38	13.93	43.85
42.	54.62	22.31	13.08	12.31	35.38	23.08	14.62	16.17	8.46	43.08
43.	54.62	26.15	24.62	14.62	32.31	26.15	13.85	16.15	14.62	34.62
44.	51.54	26.17	46.15	16.15	30	22.31	10.77	15.38	16.92	45.38
45.	50.77	0	41.54	14.62	32.31	26.15	11.54	17.69	20	34.62
46.	43.85	0	53.08	18.46	33.85	22.32	13.08	18.46	21.54	40
47.	44.62	0	33.85	25.38	50	40	10.77	21.54	20	44.62
48.	35.38	0	12.31	19.23	52.31	32.31	14.62	23.08	30	42.31
49.	31.54	0	11.54	18.46	53.85	30	14.62	23.86	35.38	36.15
50.	26.15	0	13.08	15.38	55.38	33.85	15.38	29.23	30.77	0
total	1530.08	1960.79	1150.52	802.34	1945.4	1145.51	865.42	1625.42	1298.55	939.24
Mean of each specimen	30.6016	39.2158	23.0586	16.0468	38.908	22.9102	17.3084	32.5084	25.971	18.7848

Annexure-14: Measurements of marginal discrepancy of Autopolymerizing resin specimens which were stored for 24 hours at ambient temperature and measured after casting at 50 sites.

G2 2b(ac)- Autopolymerising resin ,kept at ambient temperature for 24 hours and measured after casting G2 2b(1,2,…10)- no of specimens ,MS(1…50)- measuring sites.

MS	G2 2b 1 ac	G2 2b 2 ac	G2 2b 3 ac	G2 2b 4 ac	G2 2b 5 ac	G2-2b-6ac	G2-2b-7ac	G2-2b-8ac	G2-2b-9ac	G2-2b-10ac
1.	76.15	133.85	20	32.31	20	22.31	19.23	50	40	11.56
2.	82.31	125.38	36.15	43.85	32.31	31.54	19.23	46.15	42.31	11.54
3.	101.54	123.08	43.85	36.15	36.15	34.62	20	43.85	35.38	17.69
4.	103.08	127.69	32.31	20	43.85	34.62	24.62	49.23	40	21.54
5.	106.15	120	24.62	32.31	42.31	33.85	20.77	50	36.15	19.23
6.	102.31	116.15	42.31	24.62	32.31	33.08	20	49.23	30.77	22.31
7.	102.31	108.46	32.31	42.31	24.62	39.23	20.77	47.69	33.85	26.93
8.	109.23	106.15	23.85	26.92	26.92	43.85	19.23	44.62	36.15	19.23
9.	106.92	94.62	23.85	23.85	23.85	51.54	20.77	44.62	33.85	27.69
10.	120	106.92	26.92	23.85	23.85	44.62	21.54	43.85	32.32	33.85
11.	104.62	114.62	31.54	29.23	23.85	48.46	42.31	23.08	60	50.77
12.	111.54	114.62	23.85	23.85	31.54	45.38	44.62	15.38	61.54	53.08
13.	115.38	116.15	29.23	31.54	29.23	46.15	39.23	13.85	60.77	53.08
14.	120	126.15	23.85	23.85	25.38	47.69	40	0	60.77	56.92
15.	124.62	116.92	28.46	26.15	28.46	46.15	37.69	0	56.92	53.08
16.	116.15	121.54	30	25.38	26.15	46.92	31.54	0	58.48	60
17.	104.62	120	36.93	30	36.93	43.08	35.38	0	56.92	46.92
18.	82.31	117.7	33.47	33.47	30	49.23	33.08	0	53.08	57.69
19.	62.31	121.54	26.15	36.93	33.47	46.15	26.15	0	51.54	60.77
20.	61.54	103.08	25.38	28.46	40.96	49.23	23.86	0	43.08	50.77
21.	63.08	120	30	40.38	41.54	23.08	16.92	39.23	52.31	32.31
22.	68.46	147.69	41.54	30	40.38	24.62	16.15	45.38	53.08	30
23.	80.77	143.85	52.31	47.69	30	28.46	14.62	43.08	50.77	31.54
24.	98.46	144.62	90	73.85	58.46	22.31	15.38	41.54	51.54	30
25.	100.77	147.69	73.85	52.31	52.31	23.08	15.38	38.46	53.85	30
26.	108.46	126.92	47.69	41.54	47.69	20	13.85	36.92	62.31	30
27.	107.69	126.92	40.38	90	73.85	23.9	13.85	33.08	65.38	30.77
28.	112.31	120.77	40.96	58.46	68.46	18.46	13.08	33.08	64.62	30
29.	113.08	126.92	68.46	67.69	67.69	15.38	13.08	31.54	64.62	31.54
30.	116.92	131.54	58.46	68.46	76.15	12.31	13.08	26.15	56.92	33.08
31.	130	103.08	76.15	60.77	60.77	26.15	9.26	94.62	30	26.15
32.	120	115.38	63.85	76.15	63.85	29.23	10	87.69	32.31	23.85
33.	84.62	100.77	67.69	55.38	55.38	36.15	10	80.77	34.62	17.69
34.	75.38	106.15	55.38	63.85	47.69	31.54	11.54	74.62	39.23	15.38
35.	54.62	106.92	56.15	88.46	56.15	30	10.77	70.77	36.92	19.23
36.	64.62	100.77	60.77	47.69	88.46	27.69	13.85	73.08	38.46	22.31
37.	66.92	90.77	87.71	40.96	87.71	30	15.38	66.92	38.46	22.31
38.	64.62	100	88.46	56.15	69.23	33.85	16.92	59.23	40.77	20.77
39.	66.92	96.92	66.15	87.71	66.15	55.38	12.31	63.08	40	20.77
40.	54.62	93.08	47.69	68.46	68.46	53.08	10.77	57.01	43.08	18.46
41.	60	95.38	73.85	66.15	66.92	53.85	22.32	70.77	16.15	14.62
42.	39.23	112.31	90	69.23	73.85	45.38	23.85	64.62	0	15.46
43.	36.92	109.23	68.46	66.92	90	44.62	23.08	63.08	0	10
44.	36.92	123.85	53.08	53.08	40.01	48.46	21.54	63.85	15.38	11.54
45.	32.31	118.46	66.92	73.85	53.08	45.38	25.38	66.92	0	13.08
46.	70.77	123.85	53.08	53.08	71.54	43.85	21.54	60.77	0	19.23
47.	69.24	137.69	80	71.54	80	43.85	19.23	60.77	25.38	20
48.	66.15	161.54	83.08	83.08	83.08	38.46	0	60	33.85	17.69
49.	66.92	162.31	71.54	90	79.23	0	0	54.62	24.62	20.77
50.	66.92	151.54	69.23	80	76.92	0	0	47.69	18.46	23.85
total	4310.79	5981.54	2813.12	2912.2	2546.38	1766.22	983.15	2230.89	2006.97	1437.05
Mean of each specimen	86.2158	119.6308	56.3245	58.4296	50.9276	35.3244	19.663	44.6178	40.1394	28.741

Annexure-15- Measurements of marginal discrepancy of photopolymerising resin specimens which were stored for 24 hours at ambient temperature and measured after casting at 50 sites.

G3 2b (ac)- photopolymerising resin kept at ambient temperature for 24 hours G3 2b (1,2…10)- no of specimens, MS (1..50)- measurement sites.

MS	G3 2b 1 ac	G3 2b 2 ac	g3 2b 3 ac	G3 2b 4 ac	G3 2b 5 ac	G3-2b-6ac	G3-2b-7ac	G3-2b-8ac	G3-2b-9ac	G3-2b-10ac
1.	66.92	94.62	108.46	83.85	77.69	63.08	17.69	46.15	18.46	114.62
2.	73.08	90	100.77	93.08	91.54	53.85	15.38	47.69	16.92	113.08
3.	77.69	100.77	103.85	89.23	96.92	51.54	18.46	46.15	18.46	117.69
4.	75.4	97.69	106.92	96.92	89.23	43.85	19.23	49.23	18.46	106.15
5.	77.69	102.31	107.69	91.54	93.08	56.92	22.31	45.38	21.54	113.08
6.	66.92	94.62	118.46	77.69	83.85	46.92	15.38	45.38	20.77	106.92
7.	63.85	116.15	112.31	82.31	90	49.23	16.92	40	24.62	105.38
8.	70	126.15	113.08	79.23	86.15	43.85	14.62	45.38	20.77	90.77
9.	69.23	120.77	111.54	95.38	82.31	47.69	21.54	41.54	25.38	95.38
10.	65.38	115.38	115.38	90.77	79.23	53.08	35.38	60.77	27.69	99.23
11.	68.46	103.85	89.23	86.15	90.77	126.92	86.92	49.23	16.92	88.46
12.	74.62	130.77	93.08	90	95.38	119.23	84.62	48.46	18.46	89.23
13.	73.08	81.54	96.92	43.85	88.46	103.08	83.08	28.46	16.92	91.54
14.	80	72.31	100.77	36.15	99.23	96.15	70.77	30	19.23	84.62
15.	76.15	67.69	107.69	38.46	106.92	90	70.77	24.62	19.23	96.92
16.	80.77	84.62	97.69	106.92	38.46	81.54	61.54	26.92	19.23	96.92
17.	86.92	83.08	100	99.23	36.15	76.15	37.69	26.15	19.23	100
18.	81.54	83.85	106.92	88.46	43.85	68.46	42.31	25.38	13.08	89.23
19.	80.77	92.31	110.77	63.08	48.46	66.92	45.38	65.38	16.15	96.15
20.	82.31	81.54	106.16	57.69	45.38	62.31	51.54	41.54	18.46	90
21.	83.85	85.39	98.46	48.46	53.08	41.54	97.69	73.08	24.62	37.69
22.	82.31	88.46	110.77	58.46	57.69	41.54	89.23	73.85	30.77	33.85
23.	93.85	96.15	79.23	53.08	48.46	40	92.31	73.08	34.62	34.62
24.	91.54	103.08	81.54	45.38	58.46	45.38	93.85	67.69	43.08	44.62
25.	90.77	63.08	79.23	48.46	63.08	41.54	96.92	73.08	49.23	44.62
26.	101.54	79.23	77.69	46.16	42.31	42.31	96.15	77.69	51.54	43.08
27.	96.15	90.77	86.15	44.62	44.62	53.85	86.92	58.46	56.93	44.62
28.	114.62	95.38	89.23	46.92	43.85	55.38	82.31	45.38	46.16	51.54
29.	116.15	90	80	46.92	46.92	61.54	104.62	43.85	42.31	50
30.	119.23	93.08	93.85	43.85	44.62	53.08	86.92	77.69	33.85	50.77
31.	122.31	77.69	82.31	42.31	46.16	65.38	63.08	69.23	23.85	56.15
32.	109.23	66.15	93.08	47.69	44.62	57.69	59.23	85.38	24.62	54.62
33.	109.23	60	133.86	89.23	42.31	60	58.46	91.54	20	33.85
34.	114.62	69.23	127.7	76.92	46.92	51.54	63.08	90	23.85	33.85
35.	115.38	63.85	101.54	81.54	51.54	44.62	56.92	79.23	21.54	30
36.	107.69	60.77	90.77	77.69	47.69	47.69	63.08	81.54	23.08	26.15
37.	112.31	56.92	96.15	90.77	90.77	47.69	62.31	86.92	27.69	30.77
38.	111.54	63.08	99.23	51.54	89.23	47.69	63.08	89.23	24.62	35.38
39.	103.08	60.77	112.31	78.46	76.92	46.92	53.08	83.08	27.69	38.46
40.	86.15	53.85	110	51.54	81.54	50	62.31	79.23	27.69	33.85
41.	76.15	60	101.54	80.77	77.69	116.15	50.77	48.46	10.77	102.31
42.	90	60	110.77	78.46	78.46	106.15	52.31	46.92	13.08	106.92
43.	84.62	54.62	102.31	71.54	51.54	98.46	44.62	46.15	14.62	102.31
44.	89.23	52.31	109.23	84.62	80.77	84.62	40.78	45.38	23.08	96.92
45.	94.62	48.46	106.15	80.77	80.77	86.92	43.08	43.85	18.46	93.85
46.	101.54	80	110	77.69	77.69	80	41.54	43.85	20.77	95.38
47.	102.31	97.69	110.77	70.46	78.46	77.69	37.69	39.23	19.23	82.31
48.	106.16	93.85	100	90	90	67.69	34.62	39.23	20	93.85
49.	95.38	92.31	98.46	77.69	71.54	67.69	30.77	43.85	12.31	91.54
50.	116.15	80.77	99.23	80.77	84.62	60.77	26.33	48.46	15.38	75.38
total	4528.49	4176.96	5079.25	2965.94	3455.39	3242.29	2765.59	2778.42	1215.42	3734.63
Mean of each specimen	90.5698	83.5392	101.585	60.138	69.1078	64.8458	55.3118	55.5684	24.3084	74.6926